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ANNOUNCEMENT

Rapidly increasing costs of publication have made changes in our distribution policy necessary. We have already raised the subscription price from $2.00 to $5.00 as of July 1, 1974. Effective January 1, 1975 we are extending free subscriptions to Department employees, government agencies, educational institutions, and libraries only. All free subscriptions to individuals are terminated with this issue. Individuals may continue their subscriptions by submitting a check or money order in the amount of $5.00 to the California Department of Fish and Game, Fiscal Section, 1416 Ninth Street, Sacramento, California 95814.

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MORTALITY RATES FOR CALIFORNIA STRIPED BASS *(MORONE SAXATILIS)* FROM 1965–1971 [1]

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California Department of Fish and Game

Harvest rates on striped bass (*Morone saxatilis*) in the Sacramento-San Joaquin Estuary varied between 12 and 19% for the years 1965 to 1971. The mean harvest rate since 1965 (0.151) is 40% lower than the mean of 0.253 for the years 1958–64. Survival rates for 1965–71 varied from 61 to 69%. The mean survival rate (0.654) for this period was 21.3% higher than the 1958–64 mean of 0.539.

A decline in angler success and angler effort appears related to a declining population. Exploitation rates have declined and survival rates increased apparently in response to lower fishing pressure.

The bass tagged in 1965–66 averaged larger than bass tagged in previous years. Return rates were higher for females than for males.

INTRODUCTION

Striped bass (*Morone saxatilis*) mortality rates from 1958–64 were described for the Sacramento-San Joaquin Estuary by Chadwick (1968). These rates were based on tagging in 1958 through 1961. Our tagging program was renewed in 1965 to evaluate changes in population parameters. This paper presents estimates of 1965 to 1971 mortality rates derived from bass tagged in 1965 and 1966.

METHODS

Legal sized striped bass, 16 inches total length or greater, were captured with drift gill nets in the Sacramento-San Joaquin Estuary. These fish were tagged with disc dangler tags and released. The tagging methods are described by Chadwick (1963, 1968). Bass were tagged from April 6 to June 8, 1965 and from April 12 to May 31, 1966. Reward and nonreward disc dangler tags were used to measure angler response (the proportion of recaptured tags that were returned) each year. All reward tags had $5 reward printed on the face of the tag.

Some tags were made of cellulose nitrate while others were made of vinyl plastic. Return rates from the two tag types were compared to determine if one material was superior to the other. The wire on all tags was Type 302 soft stainless steel, 0.020 inch in diameter.

The tagging sequence was 1 vinyl nonreward; 1 cellulose nitrate reward; 2 cellulose nitrate nonreward until the supply of reward tags was exhausted. In 1965, tags were applied in the ratio of 1 vinyl: 2 cellulose nitrate after all reward tags were used. Only vinyl nonreward tags were used in 1966 after the supply of reward tags was gone. In addition to tag type, the date, tagger, fork length (FL) to the nearest inch and the condition of the bass at release was recorded. Bass which swam immediately were considered to be in good condition. Any bass

[1] Accepted for publication April, 1974. This work was performed as part of Dingell-Johnson Project, F9R, "A Study of Sturgeon and Striped Bass", supported by Federal Aid to Fish Restoration Funds.

which floated at the surface before swimming was considered in poor condition. Those bleeding profusely due to the puncturing of blood vessels by the tagging needles were placed in a third category.

Posters explaining the program and self-addressed postage paid envelopes were distributed to bait shops and marinas to encourage anglers to return tags.

Tag returns were stratified by year of recovery which was determined for each fish from the number of elapsed days between tagging and recapture. Tags recovered within 0–365 days were considered first year returns, those within 366–730 days, second year returns, etc.

Estimates of angler response and bass mortality were made using methods described by Chadwick (1968). All fish were used to estimate mortality and survival rates since condition at tagging did not affect returns. Exploitation rates were calculated for 1965 and 1966 by correcting first year returns of nonreward tags for mean response and dividing the corrected returns by the number of tags released in the spring of that year.

All nonreward returns were corrected for nonresponse and the corrected returns were divided by the estimated number of tags remaining in the population in the spring of the year to estimate exploitation rates for each year after 1966. The number extant at the beginning of each year was estimated by multiplying the number present at the beginning of the previous year by the survival rate in that year.

Expectation of death from natural causes was estimated only for 1965. This estimate was simply the sum of the exploitation and survival rates subtracted from 1.

Survival was estimated for 1965 by dividing the number of bass tagged that year into an estimate of the number still alive 1 year later. The number alive after 1 year was estimated by dividing the number of second year returns of tags released in 1965 by the exploitation rate calculated from first year returns of tags released in 1966.

Survival estimates for the years 1966 through 1971 were made by calculating the mean expectation of death from natural causes for the years 1959, 1960, and 1965, and using it as a constant. This constant was then added to the exploitation rate and subtracted from one. This method has an inherent shortcoming in that the mortality rates are dependent on a mean obtained from three observations of natural mortality and that mean may not be an accurate measure for the years 1966–71. The 1958 estimate of natural mortality was not used because it was an atypical year (Chadwick 1968).

Sommani (1972) developed another method of calculating mortality rates in years when no tagging occurs. A brief account of his method is included here since it is relatively inaccessible though useful. The example presented is for the period 1961–64 when no tagging was done. The data used are from Table 1.

Step 1—Tabulate the number of tags in the population in 1961 that were recovered in 1965 (113).

Step 2—Divide the number of tags released in 1965 (3974) into the number recovered within one year (564). The quotient (0.142) is an estimate of the harvest rate in 1965.

TABLE 1. **Estimates of Tagged Striped Bass Recaptured in the Sacramento-San Joaquin Estuary. All Returns Corrected for Nonresponse ***

Year tagged	1958	1959	1960	1961	1965	1966	1969	Total tagged
No. tagged	3,891	2,965	3,358	1,609	3,974	2,994	13,468	32,259
Year recaptured	Estimated number of recaptures							Total recaptured
1958–59	1,447							1,447
1959–60	337	732						1,069
1960–61	167	433	818					1,418
1961–62	85	180	424	306				995
1962–63	44	145	257	213				659
1963–64	23	99	236	190				548
1964–65	20	33	96	86				235
1965–66	10	16	51	36	564			677
1966–67	12	29	51	38	437	537		1,104
1967–68	1	10	27	27	262	301		628
1968–69	1	3	4	9	135	137		289
1969–70	3	15	23	18	147	163	2,342	2,711

* Response values used were 0.615 (1958–64), 0.691 (1965–68), and 0.658 (1969).

Step 3—Divide the total tabulated in Step 1 by the harvest rate calculated in Step 2. The result (796) is an estimate of the number of bass tagged prior to 1965 that were still alive in the spring of 1965.

Step 4—Estimate the number of tagged bass alive in the spring of 1961 by adding the number tagged in 1961 (1609) to the number estimated to have survived tagging in previous years. The estimate of bass surviving from 1958–60 is obtained by using Sommani's formula (3.3) repetitively for time ($t = 1959$) through 1961. This estimate is 3368 using Chadwick's survival rates.

$$(3.3) \quad T_t^{(0+1+2\ldots+(t-1))} = s_{(t-1)}\, T_{(t-1)}^{(0+1+2\ldots+(t-2))}$$

where: $T_t^{(0+1+2\ldots+(t-1))}$ = estimated number of tagged fish surviving from release at time—0, 1, 2..., $(t-1)$ to t.

$s_{(t-1)}$ = survival rate from time $(t-1)$ to t.

Step 5—Divide the estimate of the number of tagged bass alive in the spring of 1965 (796; from Step 3) by the estimate of the number of tagged bass alive in the spring of 1961 (3368; from Step 4). The quotient (0.236) is an estimate of the total survival rate for the 4 year period 1961–65.

Step 6—The total exploitation rate (0.724) for the 4-year period is obtained by dividing the number of tags recaptured (2437) during this period by the estimate of tagged fish alive at the beginning of 1961 (3368 from Step 4).

Step 7—Total mortality (0.764) for the 4-year period is the complement of survival ($a = 1 - s$).

Step 8—The mean annual instantaneous mortality rate (i) is 0.360 which is obtained from $s = c^{-it}$, where $t = 4$ years and $s = 0.236$ from Step 5.

Step 9—The instantaneous fishing mortality rate is calculated using equation 1.8 from Ricker (1958) ($p = ui/a$). All values are totals for

the 4 years ($i = 1.44$; $a = 0.764$; $u = 0.724$). The resulting p is divided by 4 to get the mean rate. The mean annual instantaneous natural mortality is $q = i - p$.

Step 10—The estimated rate of exploitation in 1961 $E(u)_{1961}$ was calculated by varying the instantaneous fishing mortality p^*_{1961} in equation (3.1) until $E(u)_{1961}$ is approximately equal to the rate of exploitation (u_t) calculated by the ratio of 1961 returns to 1961 tags released, i.e., by equation (3.4).

$$(3.4) \quad E(u)_{1961} = p^*_{1961}\frac{(i - e^{-(p^*_{1961} + q)})}{p^*_{1961} + q}$$

Step 11—The new value for p^* was then added to the mean instantaneous natural mortality q and the survival rate (s_{1961}) calculated by equation 3.5.

$$(3.5) \quad s_{1961} = e^{-(p^*_{1961} + q)}$$

Step 12—The number of tagged fish surviving to the 1962 season is now estimated and the 1962 rate of exploitation calculated using 3.1.

$$(3.1) \quad u_t = \frac{R_t(t + 1)}{T_t + T_t{}^{(0+1+2\ldots+(t-1))}}$$

where: $R_t\ (t + 1) =$ estimated recaptures of fish tagged at time (t) and recovered during (t) to $t + 1$.

$T_t =$ number of tagged fish released at time (t).

$T_t\ (0 + 1 + 2\ \ldots\ + (t -))$ as previously defined.

Step 13—Steps 9, 10, and 11 are repeated for the 1962 through 1964 estimates. Similarly, the process is repeated for the years 1967–68 when no tagging occurred.

VALIDITY OF THE ESTIMATES

Factors affecting the validity of mortality estimates are mortality due to capture, handling and tagging; tag shedding; nonreporting; and representativeness of the sample.

Tagging Mortality

The proportion of total tags returned was compared for fish in each condition (Table 2). Differences were not significant in either the 1965 or 1966 sample (1965 — $\chi^2 = 1.29$; 1966 — $\chi^2 = 0.71$). Returns from conditions 1 and 2 combined were also not significantly different from condition 3, nor was condition 2 different from condition 1. Therefore, release condition did not affect the return rate in this study. Some bass do die as a result of tagging, as evidenced by the return of a few tags each year from dead bass found by anglers, but the extent of this mortality is unknown.

Tag Shedding

Disc dangler tags are superior to all other tags used on striped bass with respect to tag shedding (Chadwick 1963, 1968). A few cellulose nitrate tags delaminated after being out several years. Delamination of vinyl tags has not been observed; however, total returns of cellulose nitrate tags slightly exceeded the total returns of the vinyl tags (Table 3). These differences were not significant for fish tagged in either year

TABLE 2. **Relationship between condition at release and proportion of tags returned**

Condition at release	Number released		Number and percentage return by year tagged			
	1965	1966	1965		1966	
			N	Percent	N	Percent
Good (1)	3,766	2,689	1,052	(27.9)	737	(27.4)
Poor (2)	154	170	41	(26.6)	51	(30.0)
Bleeding at tag wound (3)	33	135	12	(36.4)	35	(25.9)
Total	3,953	2,994	1,105		823	

(1965 — $\chi^2 = 0.60$; 1966 — $\chi^2 = 0.02$). Cellulose nitrate tags are no longer available, and the vinyl material appears to yield satisfactory results.

TABLE 3. **Comparison of cellulose nitrate and vinyl tag return rates.**

Year tagged	Tag type	Number released	Number returned by year of return (%)						
			1	2	3	4	5	6	Total
1965	cellulose nitrate	1825	176 (9.6)	143 (7.8)	80 (4.4)	49 (2.7)	47 (2.6)	18 (1.0)	513 (28.0)
	vinyl	868	79 (9.1)	69 (8.0)	34 (3.9)	16 (1.8)	20 (2.3)	8 (0.9)	226 (26.0)
1966	cellulose nitrate	1,998	258 (12.9)	132 (6.6)	68 (3.4)	67 (3.4)	27 (1.4)	--	552 (27.6)
	vinyl	996	113 (11.3)	76 (7.6)	27 (2.7)	45 (4.5)	10 (1.0)	--	271 (27.2)

Representativeness of the Sample

Most bass were tagged at Schad Landing in the western Delta (Figure 1, Table 4). In 1966, enough bass were tagged at Prisoner's Point in the eastern Delta to permit comparison of the returns for the two areas. The proportions of first year tags which were returned (12.6 and 12.9% respectively) did not differ significantly ($\chi^2 = 0.0011$).

The fishing gear and methods used are selective for large fish (Chadwick 1967). Hence, the tagged population is biased toward large fish. Some evidence for this can be found by comparing samples from the spawning populations taken by different gears. For example, the average sizes of males and females caught by anglers in the spring of 1965 were 20.6 and 26.0 inches F.L., respectively (Miller and McKechnie 1969), whereas the means for bass tagged in 1965 were 23.4 and 28.7 inches. Of course, neither sample may reflect the actual population structure.

TABLE 4. **Number of striped bass tagged at various locations in the Sacramento-San Joaquin Estuary, 1965–66**

Tagging location	Year tagged		Tagging location	Year tagged	
	1965	1966		1965	1966
Broad Slough (1)*	27	2	Chipps Island (5)	25	9
Chain Island (2)	44	0	Prisoner's Point (6)	7	411
Schad Landing (3)	3,986	2,904			
Sherman Island (4)	82	3	Total	4,171	3,329

* Numbers refer to location on Figure 1.

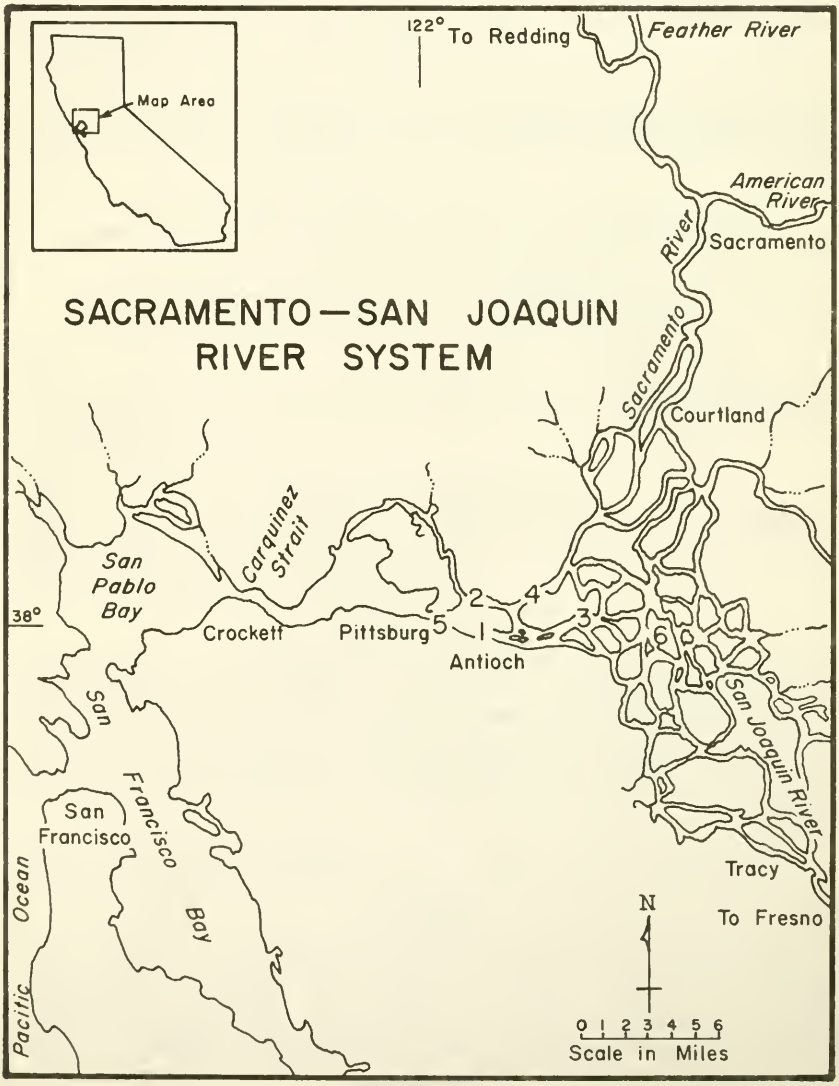

FIGURE 1. Map of study area showing tagging locations in the Sacramento-San Joaquin Estuary. Location names designated in Table 4.

Males are also over-represented because they mature earlier and remain on the spawning grounds longer than females do (Chadwick 1967, 1968; Miller and McKechnie 1969). In 1965, we tagged 2,879 males and 1,232 females, and in 1966, we tagged 2,120 males and 1,200 females. Males outnumbered females by more than 2:1 for the two years combined.

Tagging in 1965 and 1966 centered in the San Joaquin River. Netting in the lower Sacramento River was unproductive compared to the 1958–61 tagging period (Chadwick 1968). Hence, the tagged population may have been less representative of bass spawning in the Sacramento River than the 1958–61 sample. However, this bias is unlikely to affect mortality estimates significantly, since some bass tagged in the San Joaquin River are caught by anglers in the Sacramento River, and bass tagged at different locations in the western Delta in the spring (1958–61) did not have significantly different migration patterns (Chadwick 1967) or mortality rates (Chadwick 1968).

Comparisons of the size of bass tagged during this study and those tagged by Chadwick reveal some marked changes in population structure. The average size varies with sex and Chadwick sexed bass only in 1960 and 1961; hence, lengths of bass tagged in those years were compared with lengths of bass tagged in 1965 and 1966.

The fish tagged in 1960 and 1961 were smaller than those tagged in 1965 and 1966. The mean lengths of male bass in the four respective years are: 21.6, 21.7, 23.4, and 24.3 inches, F.L. The means for females for the same years are: 25.2, 25.5, 28.7, and 29.5 inches, F.L. The percentages of males $\geqq$30 inches for the four respective years were 0.9, 0.8, 10.4, and 18.4. The percentages for females $\geqq$30 inches for the four respective years were 7.6, 8.1, 39.1, and 50.3.

Changes in the size composition of the population were also apparent from mean weights of bass caught on party boats (McKechnie and Miller 1971), and from length frequencies of fish caught by anglers in the spring (Miller and McKechnie 1969).

Nonreporting by Anglers

Tags without rewards were returned at a lower rate than those with rewards. Response (r) and its variance were estimated from first-year returns using equation 1 and 2 of Chadwick (1968). The mean response (r) was estimated using Chadwick's equation 3.

Estimates of r were 0.743 for 1965 and 0.673 for 1966. Variances were 0.0195 and 0.0068 for 1965 and 1966, respectively. The mean response (r) was 0.691 for the two years. The mean response for the first 6 years of returns from the 1965 tagging was 0.740, and was 0.723 for the first 5 years of returns from the 1966 tagging. The response rate for all years combined after the first year of returns is 0.78, which suggests that response increased slightly after the first year, although chance variation is considerable from year to year (Table 5). There is no logical explanation for response increasing after the first year. This phenomenon was also noted by Chadwick (1968). Chadwick's mean rate of response for 4 sets of first year returns was 0.615, somewhat less than the value in this study. All of my mortality rates were calculated using the mean response of 0.691.

TABLE 5. **Summary of returns for the 1965–66 tagging study**

Year tagged		Number tagged	Number of annual returns						Total returns
			1965–66	1966–67	1967–68	1968–69	1969–70	1970–71	
1965	Nonreward	3,974	390	302	181	93	97	42	1,105
	Reward	197	26	28	11	6	3	0	74
	Response		0.74	0.53	0.82	0.77	1.60	∞	0.74
1966	Nonreward	2,994		371	208	95	112	37	823
	Reward	326		60	25	23	9	7	124
	Response			0.67	0.91	0.45	1.35	0.58	0.72
Total nonreward		6,968	390	673	389	188	209	79	1,928
Total reward		523	26	88	36	29	12	7	198

MORTALITY RATES

My estimates of harvest rates for 1965 (0.142 ± 0.016) and 1966 (0.179 ± 0.063) were lower than the range of 0.19 to 0.37 reported by Chadwick for the years 1958–64. From 1965 to 1971 the exploitation rate ranged from 0.119 to 0.193 (Figure 2). The mean rate of 0.151 was 40% lower than the 1958–64 mean of 0.253. Sommani's (1972) harvest rate estimates for the period 1965–68 were even lower than mine. They ranged from 0.096 to 0.176.

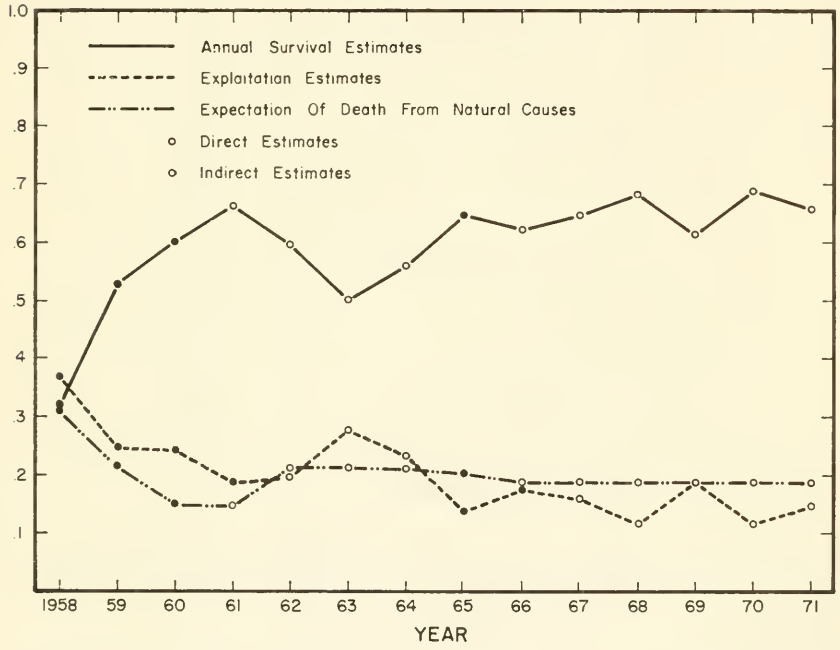

FIGURE 2. Comparison of striped bass population parameters estimated since 1958. Closed circles represent direct estimates, open circles indirect estimates.

The mean survival of 0.654 for the 1965–68 period was 21.4% higher than the 1958–64 mean of 0.539 calculated from Chadwick's (1968) data. This increase is even more pronounced using Sommani's estimates. His mean survival of 0.699 (Table 6) for 1965–68 was 29.6% higher than Chadwick's 1958–64 mean of 0.539.

The estimated expectation of natural death in 1965 was 0.203.

First year tag returns from large bass (males $\geq$24 inches and females $\geq$30 inches) generally exceeded the returns on small bass, and the overall rate of female returns was consistently higher than male returns (Tables 7 and 8). Differences in the proportions returned by sex were significant for the first year returns in both years ($\chi^2_{1965} = 8.67$; $\chi^2_{1966} = 15.47$) and for all return years combined ($\chi^2_{1965} = 25.9$; $\chi^2_{1966} = 14.85$). However returns stratified by size and sex are confounded because females average larger than males at tagging and harvest rates are highest on large fish. To minimize size effects the return rates of bass $\geq$30 inches were compared.

TABLE 6. **Comparison of mortality and survival estimates made using methods described by Chadwick (1968) and Sommani (1972)**

Year	Survival rate	Exploitation rate	Expectation of death from natural causes	Instantaneous mortality		
				Total	Fishing	Natural
1965	0.655	0.142	0.203	0.42	0.17	0.25
1966*	0.628	0.179	0.193	0.46	0.22	0.24
1967	0.647	0.160	0.193	0.44	0.20	0.24
1968	0.687	0.120	0.193	0.37	0.14	0.23
1969	0.614	0.193	0.193	0.49	0.24	0.25
1970	0.688	0.119	0.193	0.37	0.14	0.23
1971	0.660	0.147	0.193	0.41	0.18	0.23
			Sommani's Estimates†			
1965	0.664	0.136	0.200	0.410	0.166	0.244
1966	0.678	0.176	0.147	0.389	0.212	0.177
1967	0.703	0.148	0.149	0.352	0.175	0.177
1968	0.750	0.096	0.154	0.288	0.111	0.177

* Estimates below the line were made by assuming that the expectation of natural death was equal to the mean for the years 1959, 1960 and 1965. (0.193)
† Taken from Table 4, p. 30 of Sommani (1972).

The first year return rates for males and females ≧30 inches were 15.3% and 11.3%, respectively, for 1965 and 14.0% and 16.0% respectively for 1966. These differences were not significant ($\chi^2_{1965} = 1.07$; $\chi^2_{1966} = 0.50$).

Returns received through 1971 were also compared for bass ≧30 inches. Males tagged in 1965 were returned at a slightly higher rate than females tagged in 1965 (36.4% versus 36.0%); however the return rate for females tagged in 1966 exceeded the return rate for males tagged in 1966 (35.7% versus 29.1%). The 1965 differenees were not significant ($\chi^2 = 0.008$), and the 1966 differences were barely significant ($\chi^2 = 3.92$).

Chadwick (1969) reported significant differenees in returns by sex for all sizes of bass in 1960, but differences were not signifieant in 1961. More conclusive evidence regarding differences in mortality rates related to sex will likely come from a larger seale tagging program in progress since 1969.

DISCUSSION

The estimates of population parameters deseribed in this paper are biased because survival and mortality rates vary with fish size and our sampling nets select larger fish. This bias precludes determining whether Sommani's method or Chadwiek's method develops the most realistic estimates for those years when bass were not tagged.

TABLE 7. **Return of male striped bass by size at time of tagging**

Size	1965					1966				
	No. released	First year returns	Percent	Total† returns	Percent	No. released	First year returns	Percent returns	Total returns	Percent
15–17	304	26	8.6	45	14.8	233	17	7.3	41	17.6
18–19	318	22	6.9	56	17.6	193	18	9.3	33	17.1
20–21	360	28	7.8	89	24.7	244	30	12.3	56	23.0
22–23	301	15	5 0	69	37.0	190	21	11.1	43	22.6
24–25	393	27	6.9	102	26.0	192	21	10.9	44	22.9
26–27	404	39	9.6	107	26.5	224	31	13.8	69	30.8
28–29	359	44	12.3	126	35.1	286	35	12.2	89	31.1
≥30	275	42	6.5	100	36.4	350	49	14.0	102	29.1
Total	2,714	243	9.0	694	25.6	1,912	222	11.6	477	25.0
≤23	1,283	91	7.1	259	20.2	860	86	10.0	173	20.1
≥24	1,431	152	10.6	435	30.4	1,052	136	12.9	304	28.9
χ^2		9.91		8.47			3.67		19.01	

† Returns of non-reward tags through 1971.

TABLE 8. **Return of female striped bass by size at time of tagging**

Size	1965					1966				
	No. released	First year returns	Percent	Total† returns	Percent	No. released	First year returns	Percent	Total returns	Percent
≤19	8	1	12.5	3	37.5	12	0	0	0	0
20–21	13	1	7.7	1	7.7	24	1	4.2	2	8.3
22–23	49	6	12.2	15	30.6	31	3	9.7	4	12.9
24–25	141	17	12.1	41	29.1	81	11	13.6	24	29.6
26–27	214	27	12.6	66	30.8	137	14	10.2	33	24.1
28–29	294	34	11.6	105	35.7	248	32	12.9	82	33.1
30–31	239	26	10.9	84	35.1	223	31	13.9	76	34.1
32–33	123	20	16.3	51	41.4	173	31	17.9	69	39.9
34–35	58	6	10.3	17	29.3	88	19	21.6	32	36.4
≥36	36	4	11.1	12	33.3	67	7	10.5	20	29.9
Total	1,175	142	12.1	395	33.6	1,081	149	13.7	342	31.6
≤29	719	86	12.0	231	32.1	533	61	11.4	145	27.2
≥30	456	56	12.3	164	36.0	551	88	16.0	197	35.8
χ^2		0.09		1.67			4.31		8.02	

† Returns of non-reward tags through 1971.

Chadwick's method depends on the mean expectation of natural death for prior years when bass were tagged. Sommani's method is more sophisticated in that it utilized the mean instantaneous natural mortality rate calculated from tags actually returned in the non-tagging years to develop the other rates for those years. However, newly recruited fish are not represented in non-tagging years, so returns from older fish bias Sommani's estimates even more than in years when bass are tagged.

The harvest rate declined from 1958 to 1962, while the catch rate in the partyboat fishery reached its 16-year peak (Figure 3). If catchability was relatively constant, this relationship would indicate that the bass population increased during this period. The harvest rate increased 40% from 1962 to 1963. After 1963, the catch rate, harvest rates, and fishing effort all declined, (Figures 3 and 4) suggesting a decline in population.

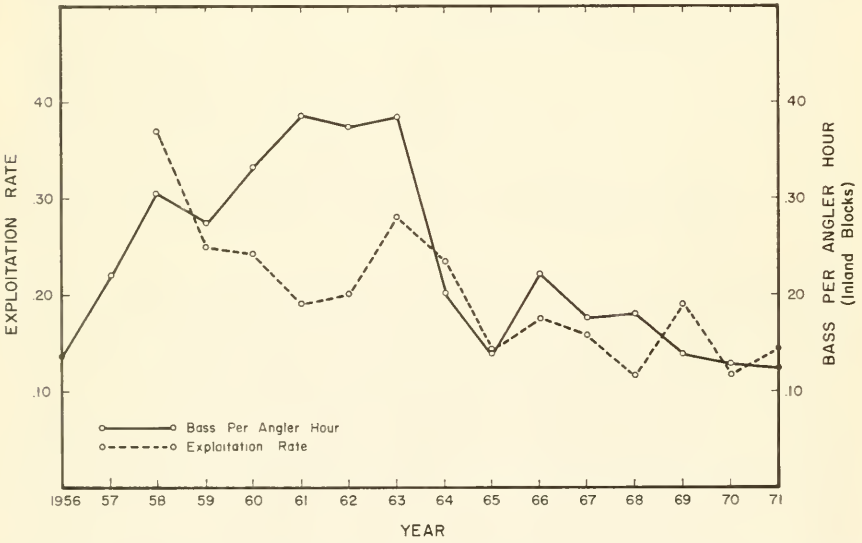

FIGURE 3. Comparison of striped bass exploitation rates and partyboat catch per angler hour. (Data from McKechnie and Miller, 1971 and Stevens, unpublished).

The decline in harvest rates is probably an indirect effect of a decline in success which likely caused the reduction in fishing effort. The significant correlation between angler success and effort as measured in the partyboat fishery supports this viewpoint ($r = 0.868$; Figure 4).

The decline in mortality rates suggest that harvest rates can be increased greatly with little reduction in yield. For example, based on Chadwick's (1969) equilibrium yield model a four-fold increase in harvest rate will increase the numbers of bass caught by 50% while reducing total weight yield about 8%. This is based on a current instantaneous fishing mortality of 0.20, an instantaneous natural mortality of 0.25, and an entry age of 3 years for the fishery. Such a change would be accomplished at the expense of reducing the average weight of bass caught by about 41%. Consequently, any regulation

FIGURE 4. Comparison of partyboat catch per angler hour and effort (angler days) in the Inland Blocks, from 1954 to 1971. (Data from McKechnie and Miller (1971) and Stevens unpublished.)

changes aimed at increasing harvest rates would have to be evaluated with regard to this trade-off between numbers and average size. It is also questionable that any acceptable means can be found to increase harvest rates, considering the apparent self-regulating relationship between harvest rates, population size, and fishing effort.

One obvious shortcoming in our measurement of population parameters is the paucity of natural mortality estimates. Intensive and sequential annual measurements of natural mortality and, hence, survival rates will eliminate the need for approximating these values. We also lack understanding of the causes of the sex, size, and mortality relationships. Current studies hopefully will better define these relationships. The environmental changes that occur due to developments such as the California Water Project, require that population parameters be precisely determined through adequate monitoring of the adult population.

ACKNOWLEDGEMENTS

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A VEHICLE-MOUNTED DIRECTIONAL ANTENNA SYSTEM FOR BIOTELEMETRY MONITORING[1]

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A vehicle-mounted dual yagi antenna was constructed for use with a D.F. receiver in monitoring gray fox (*Urocyon cinereoargenteus*) activity periods. The antenna is essentially unidirectional with an extremely sharp null. This characteristic, coupled with direct-compass attachment to a rotating antenna mast, made it possible to quickly determine signal direction with a precision of ±1° in over 2,000 instances.

INTRODUCTION

Biotelemetry equipment has made intermittent or continuous monitoring of animals possible by communicating location and, occasionally, other physical and physiological information.

Numerous descriptions of this type of equipment have appeared (Will and Patric 1972, Schladweiler and Ball 1968).

Little attention has been devoted to the receiving antenna, which is as important as the transmitter or receiver. The ideal antenna should provide high gain for long distance reception while having keen directivity for precise bearing determination. The system described possesses both of these characteristics and was used by the senior author with 150–151 MHz transmitters and receivers constructed by Davidson Electronics Company (2415 Glenwood Ave., Mpls., Minn. 55405) to study the gray fox (*Urocyon cinereoargenteus*) in California's Sacramento Valley.

This project required accurate determination of an animal's location from distances of approximately 0.4–0.8 km (0.25–0.5 mile). Neither the commonly used single loop nor yagi antenna (Mackay 1970), although directional, provided the necessary bearing resolution. A dual yagi antenna arrangement, similar to that used atop 21.3 and 30.5 m (70 and 100 ft) towers at the Cedar Creek automatic tracking station (Cochran, Warner, Tester and Kuechle 1965), was made suitable by reducing the inter-antenna distance from two wavelengths to one-half.

MATERIALS AND METHODS

The principal components of the antenna system include: mast, ball bearing race, compass, compass rose, pointer, and two yagi antennas.

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The bottom section of the 9.8 m (30 ft), three-element, telescoping television mast was attached to a pickup truck bed and rack (Figure 1). A ball bearing race connected to the top of this stationary section supported, by means of a locking bolt (Figure 2), the weight of the remaining two sections and allowed them to rotate. Affixed to the ball bearing race was an aluminum compass rose, adjustable pointer and wooden compass arm (Figure 2).

FIGURE 1. Senior author reads compass affixed to wooden arm extended from mast. Headphones are removed to prevent compass deflection while determining bearing. Nighttime bearings are read with a battery operated light taped to mast.

A Suunto compass (Code KB-14/360R, Forestry Suppliers, Inc., 205 West Rankin St., Jackson, Miss. 39204) was secured in a depression at the end of the compass arm (Figure 2). The compass arm was long enough to prevent magnetic deflection of the compass card by the antenna mast.

A beam bolted to the top section of the mast supported two yagi antennas (Hy-Gain Model 23, Hy-Gain Electronics Corp., Rural Route 3, Lincoln, Neb. 68505). This hybrid antenna (Figure 1) is a broad-

side array, using two vertically polarized three-element yagi antennas in the end fire position, spaced exactly 0.5 wavelength apart [$\lambda = c/f$, where λ = wavelength in meters, $c = 3 \times 10^8$ M/sec, f = frequency in Hz (cycles per second)]. Each antenna was coupled to a common tee connector with a 52 ohm coax transmission line that measured precisely 0.25 wavelength from the tee's center to the antenna terminals. The remaining lead connected the tee to the receiver.

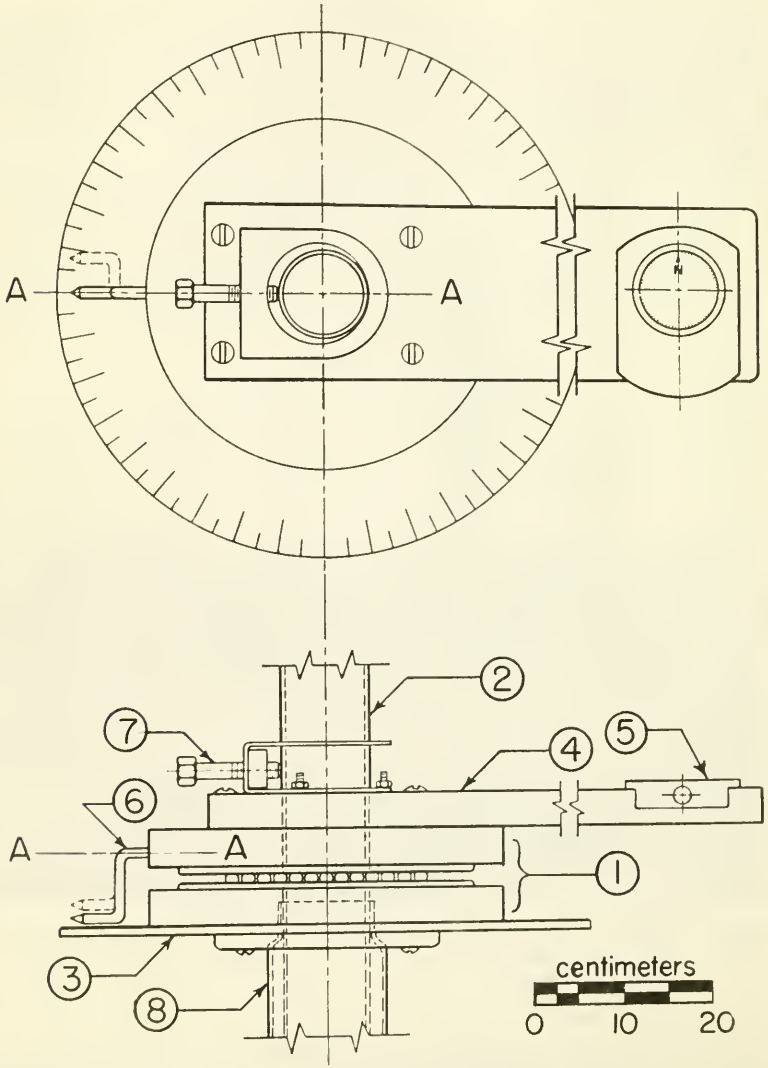

FIGURE 2. Principle components used to determine null limits and direction of the null's bisection. The parts are (1) ball bearing race attached to wooden discs; (2) rotating mast; (3) aluminum compass rose; (4) wooden compass arm; (5) Suunto compass recessed into compass arm; (6) adjustable pointer that rotates about axis A—the rotated position is shown by broken lines; (7) locking bolt that prevents rotating mast from sliding into stationary mast; (8) stationary mast.

The system combines the forward high-gain properties of the single yagi antenna (Figure 3C) with the directional qualities of the loop antenna (Figure 3B) by resorting to an array of two yagi antennas.

Figure 3A depicts the relative signal response achieved with this arrangement. Spacing between the antennas is critical. Altering the distance will result in different antenna patterns by increasing the number of lobes (Kraus 1950), as was experienced by Cochran (1967). The front to back asymmetry allows the antenna to be directed toward the incoming signal, virtually eliminating the ambiguous characteristic of most loop antennas that align toward and 180° away from the signal (Mackay 1970). The system further improves upon the loop's 90° "null-to-maximum" signal response (Figure 3B) by reducing it to 37° (Figure 3A). This effectively increases the gain, allowing better

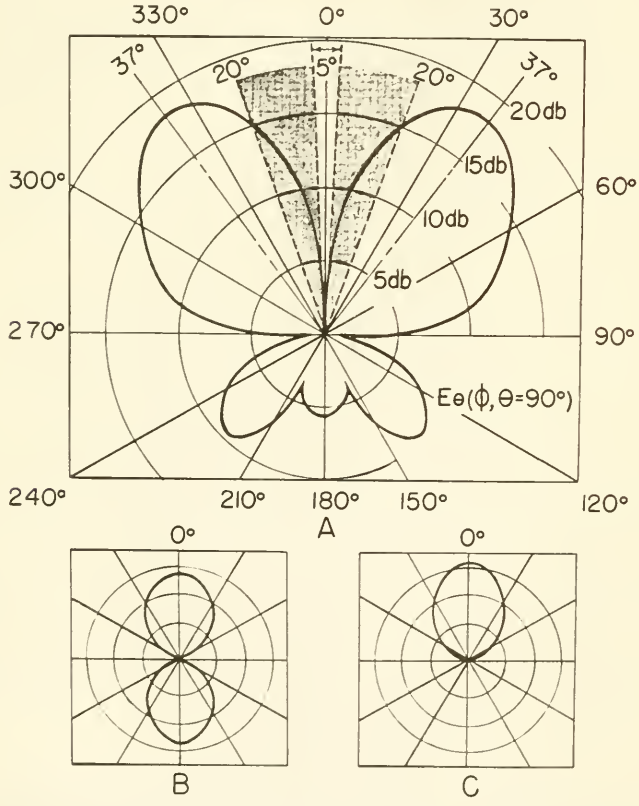

FIGURE 3. Relative signal responses characteristic of various antenna configurations are shown. Plane of antenna in each case is directed toward the incoming signal at zero degrees and each direction pattern is vertically polarized.

A. Actual signal response characteristic of this dual yagi array. Maximum response occurs 37° each side of null. Shaded areas represent the range of null limits most frequently obtained under field conditions.

B. A single loop antenna produces two symmetrical lobes with maximum signal response at 0° and 180°. Minimum response occurs at 90° and 270° (Cochran and Lord 1963).

C. A single Hy-gain Madel 25 yogi array produces only a forward lobe with maximum gain at 0°. Minimum gain is found from 90° through 270° (Hy-Gain Electronics Corp.).

null definition, and thereby more accurate direction determination when bisecting the null.

Antenna tuning, if required, may be accomplished with a grid-dip meter (calibrated frequency meter). Unequal tuning may produce an asymmetry that is skewed away from the zero-degree orientation. However, small amounts of graphical skewness remain essentially linear, and, along with the magnetic declination, may be compensated for by compass arm alignment with the center of the antenna null.

Over 2,000 directional fixes have shown the null's width to vary inversely with the signal strength. Typically, the null was 5°–40° wide, with 15° most common. Generally, when the null exceeded 40° the signal was too weak to give reliable bearings, and when less than 5° the signal was very strong (Figure 3A).

Direct compass attachment to the rotating mast made it unnecessary to align the vehicle in some predetermined manner (Verts 1963), prior to establishing the signal's direction, or to realign the compass with the antenna (Trapp 1973) each time a bearing was taken. The Suunto compass was well-suited for this application as the compass card comes to rest rapidly and could be read directly to the half degree.

The pointer and compass rose were used only to facilitate precise location of the null's limits and its bisection. Use of an adjustable pointer helped eliminate observer bias when several bearings were taken in rapid succession. This was accomplished by a 5°–10° pointer rotation about axis A (Figure 2) after each bearing, which in effect placed new limits on the null each time the pointer was rotated. The value of taking multiple bearings on gray foxes decreased as their movement increased. Nevertheless, taking at least two bearings gave some idea as to the rate of animal travel, its direction, and most importantly reduced the chance of mistaken reading.

Contingent upon animal movement and signal strength, actual field observation almost always gave bearing precisions of $\pm 1°$ or better (precision of $\pm 0.25°$ was not uncommon). This translates into a linear error of $\pm$ 14.3 m (46 ft) or less at a distance of 0.8 km (0.5 mile).

The antenna system required less than 1 day to construct and required little maintenance. Its ruggedness allowed vertical transport of antenna and mast (Figure 1) over gravel roads at 40 km/hr (25 mph), and at freeway speeds when horizontally supported by the pickup rack. Its light weight, 15 kg (33 lb), allowed one person to quickly raise the system to the vertical position. Once erected, multiple bearings could be taken in rapid succession.

ACKNOWLEDGMENTS

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TWO NEW SPECIES OF SEA BASSES OF THE GENUS *DIPLECTRUM*, WITH A KEY TO THE PACIFIC SPECIES[1]

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There are eight known species of the serranid genus *Diplectrum* in the eastern Pacific: *D. conceptione*, *D. euryplectrum*, *D. macropoma*, *D. maximum*, *D. pacificum*, *D. sciurus*, and *D. eumelum* n. sp. and *D. labarum* n. sp. The species may be distinguished on the basis of numbers of fin rays, scales and gill-rakers, body shapes, length of fin spines, and shape of spine cluster. A key is given, and meristic data are presented. The range of *D. maximum* is extended north from Peru to Baja California, and the distinctively colored juveniles are described for the first time.

INTRODUCTION

The serranid genus *Diplectrum* consists of 11 known species. All are rather small for sea basses (25–30 cm) and live on the continental shelf on sand or mud bottoms. They are commonly taken along with shrimp, and are abundant in their habitat. Although they are not now much utilized commercially, they do represent a potential resource. Also, they are collectively the most abundant, and probably the most important, serranid predator in their habitat.

Although seven eastern Pacific species have been described, the genus has never been reviewed. Walford (1937) gave a key which distinguished the four species which occurred north of the equator. Hildebrand (1946) presented a key which distinguished the four Peruvian and Panamanian species, including the southern *D. conceptione*, and described a new form, *D. maximum*. Subsequently Hildebrand (1948) described another new species, *D. mexicanum*, from the Gulf of California.

Our data indicate that there are eight species of *Diplectrum* in the eastern Pacific, and that two of these are undescribed. *D. mexicanum* Hildebrand 1948 is identical to *D. macropoma* Gunther 1864. It is our purpose to describe the new forms, and present sufficient data on the others that they may readily be identified. Meristic and morphometric data for all species but *D. conceptione* are given in Tables I–III. We have examined no material of *D. conceptione*.

MATERIALS AND METHODS

Specimens utilized for this study are housed at the Scripps Institution of Oceanography (SIO) and the Fish Collection, Department of Zoology, University of California, Los Angeles (UCLA). Counts and measurements were made according to the methods of Hubbs and Lagler (1958). Rows of scales on the opercle have often been used as a taxonomic discriminator in *Diplectrum*. Although we made these counts, we experienced difficulty in obtaining consistent, repeatable data.

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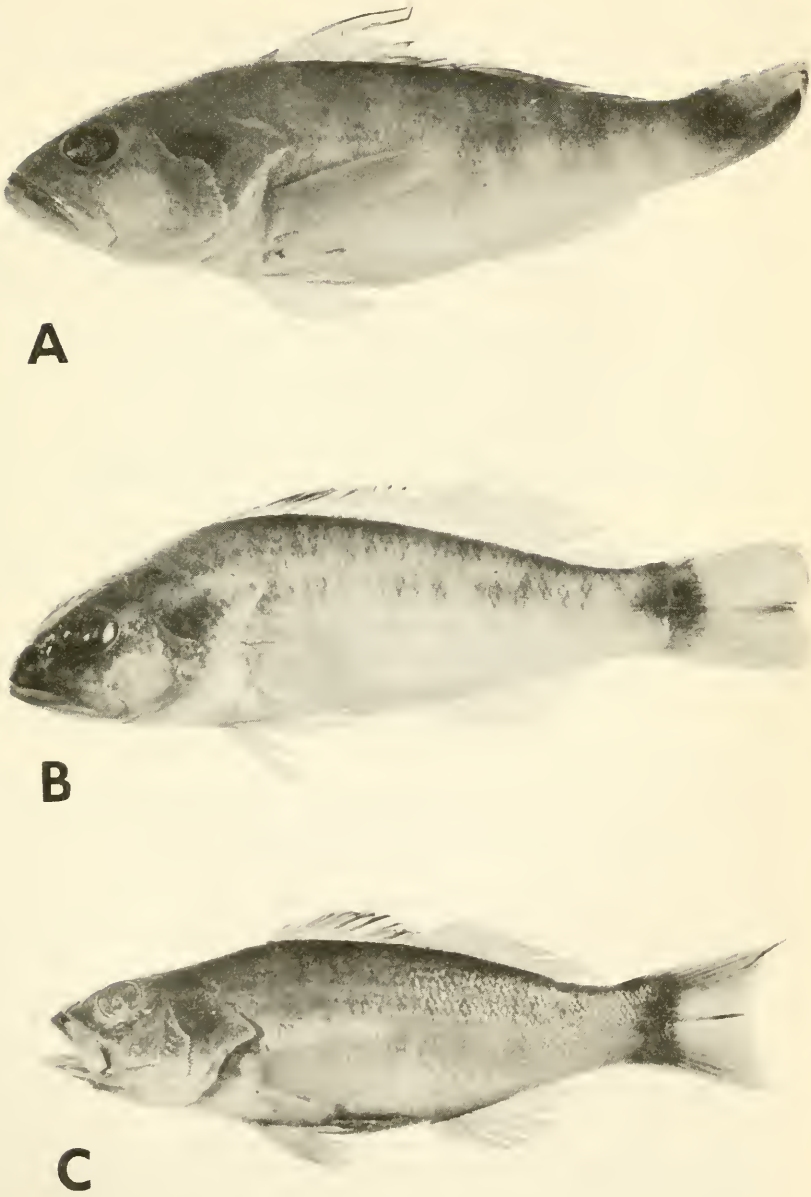

FIGURE 1. Three species of *Diplectrum;* A, holotype of *D. labarum* (right side, reversed), B, holotype of *D. eumelum,* C, *D. macropoma,* a 137 mm individual from the Gulf of California (SIO60-95).

DIPLECTRUM HOLBROOK

The following combination of characters distinguishes *Diplectrum* from other Pacific serranid genera:

D.X. 12; A.III. 7 or 8 (occasionally 6 or 9); body elongate, moderately compressed; top of head naked from occiput forward; caudal lunate to slightly forked; scales moderately large, 50–80 rows above lateral line; preopercle produced into bony flap and armed with 1 or 2 clusters of strong, divergent spines.

KEY TO THE PACIFIC SPECIES OF *DIPLECTRUM*

1a. Second, 3rd, and 4th (occasionally 5th) dorsal spines with black, filamentous extension; the 3rd spine longest, often reaching to base of 9th spine when depressed; 2nd spine at least twice as long as 1st (See species account for specimens <60 mm) ..... *labarum*

1b. Dorsal spines without black filamentous extensions; the 3rd spine not the longest; 2nd spine less than twice as long as 1st 2

2a. 22 or more gill-rakers on lower limb of first gill arch; no large black area on inner membrane of opercle ..... *sciurus*

2b. 17 or fewer gill-rakers on lower limb of first gill arch; a large black area on inner membrane of opercle, visible externally as a dark spot above spinous projection of preopercle 3

3a. 3rd anal spine scarcely if any longer than 2nd; lower jaw projecting strongly, its tip entering the dorsal outline of head ..... *maximum*

3b. 3rd anal spine notably longer than 2nd; lower jaw not projecting sufficiently to enter dorsal outline of head 4

4a. 3–4 much enlarged spines at angle of preopercle ..... *conceptione*

4b. At least 6 spines at angle of preopercle, radiating from a single, broad center 5

5a. 8–11 oblique scale rows on cheek 6

5b. 6 oblique scale rows on cheek 7

6a. Head large (2.2–2.5 in std. length); caudal peduncle very shallow (3.8–4.6 in head); spinous projection of preopercle always deeper than length of eye (in specimens as small as 60 mm may be just equal); dark bar at base of soft dorsal; ventral fins dusky; anal soft rays usually 8 ..... *curyplectrum*

6b. Head smaller (2.7–2.9 in std. length); caudal peduncle deeper (2.7–3.0 in head); spinous projection of preopercle usually not as deep as length of eye; no dark bar at base of soft dorsal; ventral fins colorless; anal soft rays usually 7 ..... *pacificum*

7a. Body deep (2.8–3.4 in std. length); caudal peduncle quite deep (2.8 or less in head); snout straight and somewhat pointed; 19–27 pseudobranch filaments; 9th dorsal spine notably shorter than 10th; dorsal and anal soft rays decreasing in length posteriorly; in isopropanol no pale spots on preorbital or pale stripe on cheek; soft dorsal not spotted, but top half with a dusky bar ..... *macropoma*

7b. Body moderately deep (3.0–4.2 in std. length); caudal peduncle shallow (3.0–3.2 in head); snout blunt, curving convexly at tip; 27–37 pseudobranch filaments; 9th and 10th dorsal spines subequal; posterior soft dorsal and anal rays as long as or longer than anterior rays; orange stripe passing from preopercle anteriorly across cheek, breaking up into 3 distinct spots on preorbital (pigmented areas definitely pale in isopropanol); soft dorsal spotted ..... *cumelum*

DIPLECTRUM LABARUM N. SP.

Description

D.X, 11–13 (12.0); A.III, 6–8 (7.1); pectoral 15–18 (16.6); gill-rakers 6–9 + 13–15 (8.1 + 14.0); pseudobranch filaments 23–36 (28.9) lateral line scales 47–49 (47.8); scale rows above lateral line 52–61 (56.7); oblique scale rows on cheek 7–8 (7.3). Measurements of body parts are given in Table III. Meristic data are in Tables I and II.

Body moderately deep, caudal peduncle rather shallow; anterior dorsal profile gently convex, a slight depression just back of occiput; snout well rounded; mouth oblique; maxillary extending to a point just behind rear margin of pupil in large specimens, somewhat anterior to this in small specimens. Teeth in the jaws in villiform bands, some of the outer ones in the upper jaw enlarged, both outer and inner teeth in the lower jaw enlarged anteriorly, with a single enlarged row posteriorly; palatine teeth in narrow villiform bands; vomerine teeth in a triangular patch, villiform with a few enlarged at the two posterior apices. Gill-rakers at angle of first arch approximately $\frac{1}{2}$ length of eye; longest filament about $\frac{2}{3}$ length of eye. Spinous projection of preopercle deep and square; posterior margin straight, inclined slightly backward (almost vertical in smaller specimens); lower margin inclined slightly upward and approximately twice as long as upper margin which is inclined slightly downward; a single cluster of large, closely spaced diverging spines, uniformly decreasing in strength away from center, longest at apex of lower angle (Figure 1).

Spinous dorsal configuration unique; 2nd, 3rd, and 4th spines modified distally into slender, black, filamentous extensions; membrane between 2nd and 3rd spines deeply notched; 2nd spine usually at least twice as long as 1st (juveniles may often be identified by this character before filamentous nature of spines is evident); 3rd spine the longest, often reaching to base of 9th spine and beyond when depressed; 9th and 10th spines subequal, about $\frac{3}{5}$ as long as 1st dorsal soft ray. Soft dorsal outline varies with size; in smaller specimens, rays decreasing in length posteriorly, in larger specimens posterior rays (except for 12th) equal to or longer than anterior rays. Anal with 3 small graduated spines, the 2nd the strongest; soft margin somewhat rounded anteriorly, then with a posterior slant with an acute posterior angle, longest ray usually 2nd or 3rd in smaller specimens, 6th in larger specimens, middle rays the longest, reaching beyond tip of ventral, but falling well short of anal origin; caudal nearly truncate, with upper rays a little longer than the lower. Distal margin of pectoral fin inclined obliquely backward from third to tenth ray then with an anterior slant.

Color in isopropanol grayish-brown above, pale yellowish to silvery below; sides with 5 or 6 dark squarish blotches above, these often continuous with the same number of arcuate blotches below (these markings more or less evident in juveniles in conjunction with 2 dark longitudinal lines). Black spot on base of caudal rays very prominent, encompassing over half the caudal depth at this point; caudal rays tipped with black, the middle ones most heavily; inner membrane of opercle with a large black area, visible externally as a dark spot above spinous projection of preopercle. A dark band present just below the eye, broadening posteriorly on the cheek.

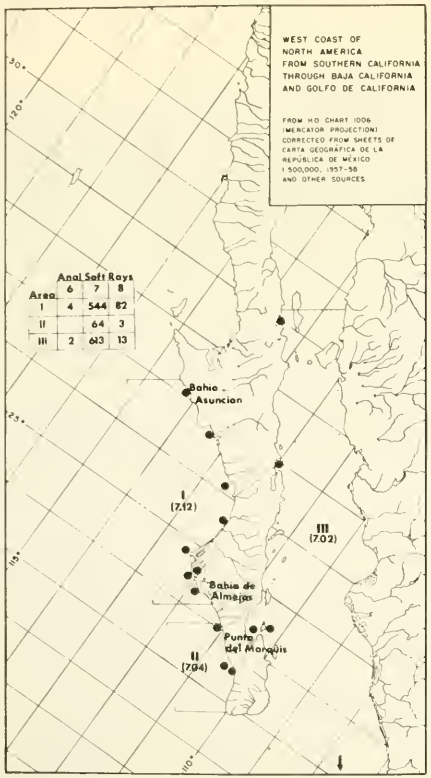

FIGURE 2. Variation in number of anal soft rays in *Diplectrum labarum*. Roman numerals indicate the areas compared (Area III extends south to Panama). The numerals in parentheses are the means for each area, the table gives the frequency distribution, and the dots indicate areas from which samples were utilized.

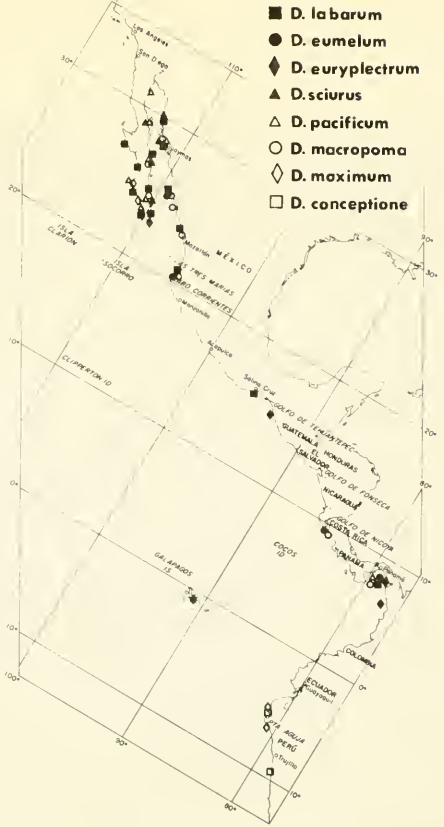

FIGURE 3. Distribution of the Pacific species of *Diplectrum* based on material examined by us with the exception of the Peru and Galapagos Islands records.

A color transparency of a 138 mm specimen from the Gulf of California shows the following markings: a dull orange line running longitudinally along the membrane of the spinous dorsal, slightly above its base; on the soft dorsal 5 dull orange diagonal bars (sloping backwards), and a very narrow line of brighter orange running just at the tips of the rays; 2 yellow stripes on the soft anal joining between the 2nd and 3rd rays; 3 dark orange vertical wavy lines on the caudal fin; the upper and lower caudal margin tipped posteriorly with reddish orange; pectorals transparent; ventrals pale to dusky. The soft dorsal and caudal markings are more or less evident in preserved specimens, but the spinous dorsal and anal markings are not.

Identification

D. labarum may be readily distinguished from its congeners on the basis of the unique spinous dorsal configuration. In the other species, the 2nd and 3rd dorsal spines are much shorter and stronger, without the black filamentous extensions. In specimens smaller than 100 mm, the black, filamentous nature of the dorsal spines is often not yet apparent; however, these individuals may still be identified by the fact that the 2nd spine is more than twice as long as the 1st. Specimens less than 60 mm in length may even be lacking this character in which case they are most easily confused with *D. pacificum*, as the color pattern is similar, and the preopercle is not yet developed to the point of distinction. Cheek scale count is probably the best character to use at this stage (*D. labarum*, 7–8; *D. pacificum*, 9–10) keeping in mind that there may be some overlap.

Derivation of Name

From the Latin *labarum*, the Roman imperial standard, in allusion to the elongated dorsal spines.

Range

Outer coast of Baja California as far north as Bahía Asunción; Gulf of California as far north as Bahía de los Ángeles and Punta Tepoca, extending southward along the Mexican coast to the Gulf of Panama (Fig. 3).

Variation

It was apparent from an inspection of the data that individuals with 8 anal rays occurred more frequently in samples taken between Almejas and Asuncion bays, Baja California. For purposes of analysis the range of *D. labarum* was divided into three areas; (I) outer coast of Baja California north of Almejas Bay, (II) outer coast south of Almejas Bay, and (III) Gulf of California to Panama (Fig. 2).

Although the means for the areas do not differ greatly, the differences between Areas I and II and I and III are significant at the $p \leqq .05$ level when tested by the Student's t-test. The means for Areas II and III could not be separated. In order to avoid certain assumptions required by the Student's t-test, the median test, a nonparametric procedure (Tate and Clelland 1957), was applied, and the results were the same. The data for Area II are given separately, since the relatively small sample size does not allow us to preclude the possibility of intermediacy. However, lumping Area II with either Areas I or III does

not affect the results of the analysis. This does not indicate that the Area II population is intermediate, only that the available samples are small in relation to the samples for Areas I and III.

Since this variation is characterized by northern populations having a higher frequency of individuals with 8 anal rays (rather than 7), one might initially attempt to explain it as a phenotypic effect of water temperature. However, temperature data (Griffiths 1968) indicate surface temperatures in Area II actually differ more from those in III than from those in I. If anal ray counts were being significantly affected by water temperatures, one might then expect to find a north-south cline of this character in Area III. This is not the case. It might further be expected that other counts would be higher in Area I. This is, however, not true for dorsal and pectoral rays, for which a large number of specimens was examined.

Although the hypothesis of environmentally induced variation cannot be discarded, it does not seem consistent with the data at hand. Whether the differences are genetic or not, it is clear that there must be restricted mixing of individuals between Areas I and II in order for this variation to exist. Such restriction is somewhat surprising in a supposedly vagile species such as this which produces large numbers of eggs and pelagic larvae. Our current understanding of the hydrography of the outer Baja coast provides no explanation for any sort of pelagic barrier between Almejas Bay and the Marquis Point vicinity, and as we know very little about the ecology and behavior of *D. labarum,* we must defer further speculation as to the cause of this phenomenon to future studies of this species or other fauna of the area. At present, sufficient specimens to allow similar analysis of other species of *Diplectrum* occurring here are not available.

DISCUSSION

D. labarum is the most common *Diplectrum* in SIO trawl collections from the outer coast of Baja California and the Gulf of California, and appears to be fairly common throughout its range. It occurs most frequently in the Gulf with *D. sciurus* in depths of 36–72 m, but has been taken with all the Pacific species except *D. maximum* and *D. conceptione.* Its complete absence from the literature is difficult to explain, particularly in light of its unique appearance and the fact that it occurs as far south as Panama where lack of sampling and descriptive effort has certainly not been a problem. Whether this absence results from a failure of recognition or a real lack of material could only be determined by an extensive examination of earlier collections.

MATERIAL EXAMINED

Holotype—SIO65-160, a 176mm SL individual from Bahía de Banderas, Jalisco, Mexico, taken on 2 June 1965 by otter trawl on a muddy sand bottom at 31–35 m by T. Matsui and C. W. Jerde.

Paratypes—Mexico, Baja California Sur—Bahía Asunción, SIO64-892, 1 (123); Bahía Ballenas, SIO64-270, 28 (48–73); SIO64-820, 7 (50–75); SIO64-889, 145 (19–133); Punta Pequeña, SIO64-886, 16 (112–164); SIO64-887, 18 (35–123); SIO64-888, 193 (39–146); Punta San Juanico, SIO69-235, 21 (57–151); Boca Ánimas, SIO69-234, 5 (68–128); SIO64-883, 28 (119–177); SIO64-884, 42 (35–135); Cabo San Lazaro, SIO64-880, 5 (38–137); Isla Magdalena, SIO64-881, 47

(33–176); SIO64-882, 18 (114–176); Bahía Magdalena, SIO62-112, 2 (44–60); SIO64-20, 3 (95–151); Isla Margarita, SIO64-877, 48 (48–138); SIO64-879, 2 (124–128); Bahía Almejas, SIO64-876, 44 (24–67); Punta del Marquis, SIO62-701, 5 (152–172); SIO62-702, 11 (60–66); SIO62-708, 7 (18–48); SIO62-709, 36 (59–192); SIO62-867, 1 (59); SIO64-871, 1 (178); Vicinity Todos Santos, SIO64-866, 6 (54–63); SIO64-868, 1 (162); Mexico, Gulf of California—Punta Tepoca, SIO 60-120, 6 (106–124); Bahía Los Ángeles, SIO62-236, 106 (65–185); SIO61-282, 3 (93–212); Cerro Colorado, SIO70-70, 7 (73–108); Bahía Santa Inéz, SIO65-304, 63 (72–174); SIO65-305, 2 (100–190); SIO68-71, 57 (50–156); SIO68-72, 21 (58–161); SIO68-73, 18 (68-126); SIO 68-74, 14 (46–158); SIO68-75, 21 (57–159); Punta San Telmo, SIO65-285, 31 (14–88); Topolobampo, UCLA56-118, 1 (63); Isla Espíritu Santo, SIO68-66, 7 (62–75); SIO68-67, 18 (59-110); SIO70-62, 1 (52); Bahía La Paz, SIO65-257, 133 (75–150); SIO65-350, 2 (98-103); Punta Gorda, SIO65-250, 1 (139); Mexico, Sinaloa-Tres Islas, SIO66-520, 1 (54); El Dorado, SIO59-262, 1 (133); Boca Tecapán, SIO60-90, 10 (72–122); SIO62-75, 70 (43–74); Mexico, Nayarit—off Laguna de Agua Brava, SIO62-76, 20 (63–139); Islas Las Tres Marías, SIO60-89, 4 (91–135); San Blas, SIO59-270, 4 (96–123); Mexico, Jalisco—Bahía Banderas, SIO62-51, 2 (89–117); SIO65-160 taken with the holotype, 9 (88–178); Mexico Oaxaca—Golfo de Tehuantepec, SIO63-503, 23 (40–118); SIO63-504, 17 (29–110); SIO63-514, 2 (69–132); SIO63-518, 1 (40); SIO63-524, 10 (34–76); SIO63-526, 10 (38–58); SIO65-164, 124 (38–77); Panama, SIO70-218, 1 (65); SIO71-249, 4 (104–130); SIO 71-57, 34 (72–162).

DIPLECTRUM *EUMELUM* N. SP.

Diplectrum macropoma (not of Gunther), Jordan and Eigenmann, Bull. U.S. Fish Comm., VIII, 1888 (1890), 397; Jordan and Evermann, Bull. U.S. Nat. Mus., LXVII, 1896, 1205; Meek and Hildebrand, Field Mus. Nat. Hist., Publ. 226, zool. ser., XV, pt. 2, 1925, 475. Orces, G. Ciencia y Naturaleza, 2 (2), 1959, 81.

Description

D.X, 12; A.III, 7; pectoral 16–17 (17.0); gill-rakers 7–8 + 12–13 (7.3 + 12.7); pseudobranch filaments 27–37 (32.1); lateral line scales 47–50 (48.5); scale rows above lateral line 51–60 (56.1); oblique scale rows on cheek 6–7 (6.0). Measurements of body parts are given in Table III. Meristic data are in Tables I and II.

Body moderately deep, back slightly elevated, caudal peduncle fairly shallow; anterior dorsal profile straight or slightly concave from base of spinous dorsal to interorbital, gently convex from this point to tip of snout which is broad and blunt; mouth quite oblique; maxillary extending well beyond pupil to rear margin of orbit in some specimens. Teeth in the jaws in villiform bands, some of the outer ones enlarged in the upper jaw, both inner and outer teeth enlarged in the lower jaw anteriorly, with a single row of enlarged teeth posteriorly. Palatine teeth in narrow villiform bands. Vomerine teeth in a triangular patch, villiform with a few enlarged at the two posterior apices. Gill-rakers at angle of first arch less than $\frac{1}{2}$ length of eye; longest filaments about $\frac{2}{3}$ length of eye. Spinous projection of preopercle deep; posterior mar-

gin straight, inclined backward forming an obtuse angle with the lower margin, resulting in a notably produced lower angle; lower limb of preopercle smooth, continuous in profile with lower shelf of spinous projection; upper limb of preopercle finely serrate forming a broad concavity where it joins upper margin; a single cluster of large diverging spines uniformly decreasing in strength away from center, longest at the apex of lower angle. Spinous dorsal outline fairly even with no greatly elongated spines or pronounced notch; 2nd spine less than $1\frac{1}{2}$ times as long as 1st; 4th and 5th spines longest, subequal; 9th and 10th spines subequal, about $\frac{2}{3}$ as long as 1st dorsal soft ray. Posterior dorsal soft-rays (except for 12th) equal to or longer than anterior rays. Anal with 3 small graduated spines, the 2nd only slightly if any stronger than the 3rd; soft margin rounded anteriorly, then with a posterior slant to an acutely pointed tip; 6th ray the longest. Pectoral softly pointed, with oblique upper and lower posterior margins, middle rays the longest, reaching well beyond tip of ventral, often to a point above anal origin. Caudal barely lunate with the upper rays notably produced.

Color in isopropanol light brown above with numerous vague traces of dark cross bars, pale yellow below. Black spot on base of caudal rays large; inner membrane of opercle with a large black area, visible externally as a dark spot above spinous projection of preopercle. Membrane behind each dorsal spine tipped with a black speck; soft dorsal dusky, mottled with pale spots; middle rays of caudal tipped with black. Three pale spots on preorbital, a pale stripe extending from below eye across cheek and onto spinous projection of preopercle.

A color transparency of a specimen from Costa Rica shows the following: preorbital spots and cheek stripe bright orange; soft dorsal dull orange with colorless spots; dark area on opercle metallic blue; caudal with vertical wavy lines or orange spots; lower side with 4 or 5 faint orange longitudinal lines about 1 scale row apart.

Identification

Due to the similarity in general body shape, preopercular configuration, and cheek scale rows, *D. cumelum* is quite easily confused with *D. macropoma*, and this confusion has been widespread in the literature. *D. cumelum* has a larger head and much shallower caudal peduncle and may be most easily distinguished with any or all of the following characters: preorbital spots and cheek stripe; 9th and 10th dorsal spines subequal; profile of snout convex, not straight; posterior soft dorsal and anal rays equal to or longer than anterior ones; soft dorsal spotted.

Derivation of Name

From the Greek *eu*, beautiful and *melon*, cheek.

Range

From Topolobampo, Sinaloa, Mexico to Panama (Fig. 3).

Discussion

In 1948, Hildebrand described a new species, *D. mexicanum* based on a 125 mm specimen taken in the Gulf of California in 1889. A close examination of this description and the accompanying illustration shows this specimen to be specifically identical with *Centropristis macropoma*

Gunther 1864. A study of the intervening literature and specimens of *D. macropoma* and *D. cumclum* indicates the source of the confusion. *D. macropoma* and *D. cumclum* are very similar in appearance, but as noted above there are several characters which readily distinguish them. In 1888, Jordan and Eigenmann apparently mistook specimens of *cumclum* for *macropoma* and listed as key characters for *macropoma*, 3 characters (pale spots on snout, pale stripe on cheek, and spotted soft dorsal) which are in fact diagnostic for *cumclum*. This concept of the species was maintained by Jordan and Evermann (1886), and in 1925, Meek and Hildebrand described as *macropoma* what again must have been specimens of *cumclum*, adding another *cumclum* character (the posterior rays of soft dorsal the longest). This, then explains how Hildebrand, upon discovering a specimen of *macropoma*, of Gunther, believed it to be a new species and described it as *mexicanum*.

Material Examined

Holotype—SIO65-160, a 129 mm SL individual from Bahía de Banderas, Jalisco, Mexico, taken on 2 June 1965 by otter trawl on a muddy sand bottom at 31-35 m by T. Matsui and C. W. Jerde.

Paratypes — Mexico, Sinaloa, Gulf of California — Topolobampo, UCLA 56–118, 1 (172); Mexico, Jalisco-Bahía Banderas, SIO62-51, 7 (109–202); SIO65-160 taken with the holotype, 8 (113–132); Costa Rica, UCLA63-142, 12 (97–110); UCLA63-148, 54 (71–232); Panama, SIO70-141, 2 (86–105); SIO70-218, 24 (98–145); SIO71-57, 8 (82–229); SIO71-249, 2 (140–149).

DIPLECTRUM MAXIMUM HILDEBRAND

Diplectrum conceptione Evermann and Radcliffe (in part, not of Cuvier and Valenciennes), Bull. U.S. Nat. Mus., 95, 1917, p. 75, pl. 7, fig. 2.

Diplectrum maximum Hildebrand, Bull. U.S. Nat. Mus., 189, 1946, p. 185, fig. 42.

D.X, 12; A.III, 7; pectoral 17; gill-rakers 6–7 + 13–14 (6.8–13.5); pseudobranch filaments 25–33 (29); lateral line scales 48–49 (48.5); scale rows above lateral line 60–70 (64.5); oblique scale rows on cheek 9. Measurements of body parts are given in Table III. Meristic data are in Tables I and II.

Body elongate, head small; caudal peduncle compressed and quite long; anterior dorsal profile slightly concave from base of spinous dorsal to interorbital, straight from this point to tip of snout which is narrow and somewhat pointed; mouth moderately oblique; lower jaw strongly projecting, its tip just entering dorsal outline of head; maxillary extending to a point directly below rear margin of pupil. Teeth as in other species. Gill-rakers at angle of first arch approximately $\frac{1}{2}$ length of eye; longest filaments less than $\frac{1}{2}$ length of eye. Spinous projection of preopercle shallow, well-rounded; no well defined upper and lower horizontal margins, the projection continuous (no sharp change in direction) with upper and lower limbs of preopercle; a single cluster of slightly diverging spines, decreasing in strength very little away from the center, longest at the center. Spinous dorsal outline moderate without a pronounced notch; the 4th spine the longest; 9th and 10th spines subequal about $\frac{2}{3}$ as long as 1st dorsal soft ray. Soft dorsal

outline with a distinct posterior slant, the anterior rays the longest. Anal with 3 spines, the 2nd stronger than and equal to or longer than the 3rd; soft margin convexly rounded, the 2nd ray the longest, posterior tip not acutely pointed. Pectoral obliquely rounded, the 4th through 7th rays the longest, reaching beyond tip of ventral, but not to anal origin. Caudal nearly truncate, the upper rays slightly longer than the lower.

Color in isopropanol: lowermost sides and belly pale; back and upper sides dark brown with 3 pale horizontal stripes; one, from just back of occiput to just below middle of soft dorsal; a second, from just behind eye to upper part of caudal peduncle, ending in a paler blotch on base of caudal rays; a third, from just above pectoral base to lower part of caudal peduncle; the upper 2 lines continuous and slightly darker than the third which is broken, consisting of a series of 9–10 very pale blotches interrupted by the darker background; a median pale line on the nape from occiput to base of spinous dorsal. Vague traces of small dark spots on snout and nape. Dark spot on base of caudal rays small (less than $\frac{1}{3}$ depth of caudal at this point) and only slightly if any darker than background color of sides; caudal dusky, the upper and lower rays darker toward their bases. Inner membrane of opercle with a large black area visible externally as a silver spot bordered posteriorly and above by black. A prominent jet black region extending across the membrane between the first four or five dorsal spines, narrowing posteriorly to a dusky stripe which continues the entire length of the dorsal fin. Pectoral and anal pale, translucent, ventral slightly dusky.

Discussion

The above description is based on 4 small specimens (67–92 mm) collected in 1962 and 1964 on the outer coast of Baja California at Bahía Magdalena and Punta del Marquis in shallow water (1–4 fathoms). The presence of these small individuals here leads us to conclude that there exists a viable, reproducing population of *D. maximum* in this area, as the transport of larvae or juveniles from the only previously noted locality, northern Peru, over 2,000 miles to the south, is unlikely.

These individuals possess at least one very prominent character, the large, jet black region on the anterior portion of the spinous dorsal, which has not been previously described for *maximum*. This may be a juvenile character, and specimens as small as these have never been described in detail. However, it could represent a real genetic difference between the South American and Baja California populations. The true relationship of these populations cannot be established until a larger number of specimens representing a wider size range from both areas becomes available.

Range

Known only from Bahía Magdalena and Punta del Marquis, Baja California, and Paita and Lobos de Tiera, Peru (Fig. 3).

Material Examined

Mexico, Baja California Sur—Bahía Magdalena, SIO62-106, 1 (68); SIO62-726, 2 (44–50); SIO64-63, 1 (92); Punta del Marquis, SIO62-706, 2 (74).

TABLE 1

Meristic Data for Seven Pacific Species of *Diplectrum*

	Dorsal Soft Rays			Anal Soft Rays				Lateral Line Scales					Pectoral Rays			
	11	12	13	6	7	8	9	47	48	49	50	51	15	16	17	18
D. labarum	5	263*	6	6†	1,153*	96	--	11	36*	3	--	--	2	112	159*	3
D. sciurus	--	21	--	--	3	118	3	--	4	15	1	1	--	--	19	2
D. maximum	--	4	--	--	4	--	--	--	2	2	--	--	--	--	4	--
D. euryplectrum	1	33	--	--	--	31	--	--	15	5	--	--	--	--	9	25
D. pacificum	2	72	2	--	75	1	--	--	7	16	--	--	--	1	22	--
D. macropoma	--	39	--	--	39	--	--	7	25	7	--	--	--	1	36	2
D. eumelum	--	39*	--	--	39*	--	--	6	11	20*	2	--	--	1	38*	--

Gill Rakers on Lower First Arch

	11	12	13	14	15	16	17	23	24	25	26	27	28	--	--	--
D. labarum	--	--	10*	29	10	--	--	--	--	--	--	--	--	--	--	--
D. sciurus	--	--	--	--	--	--	--	1	3	8	7	1	1	--	--	--
D. maximum	--	1	1	2	--	--	--	--	--	--	--	--	--	--	--	--
D. euryplectrum	--	--	--	--	3	11	3	--	--	--	--	--	--	--	--	--
D. pacificum	--	3	11	9	--	--	--	--	--	--	--	--	--	--	--	--
D. macropoma	1	12	25	--	--	--	--	--	--	--	--	--	--	--	--	--
D. eumelum	--	13*	26	--	--	--	--	--	--	--	--	--	--	--	--	--

* Count of Holotype.
† Geographically variable, see species account.

TABLE 3

Comparative Measurements of Seven Pacific Species of *Diplectrum* in Thousandths of Standard Length

	Diplectrum labarum				*D. cumclum*				*D. macropoma*			*D. maximum*			*D. sciurus*			*D. pacificum*			*D. curyplectrum*		
	R	X	N	H	R	X	N	H	R	X	N	R	X	N	R	X	N	R	X	N	R	X	N
Head length	361–424	387	16	401	373–409	388	29	388	354–387	370	25	350–364	357	4	334–385	352	15	346–375	361	15	401–455	438	10
Eye length	68– 97	86	16	81	74– 97	84	29	81	74– 90	83	25	83– 94	90	4	78– 93	84	15	59– 91	79	15	94–106	97	10
Snout length	77–108	89	16	93	81–100	89	29	91	75– 94	84	25	73– 79	77	4	75– 82	78	15	74– 95	84	15	77–107	94	10
Suborbital width	36– 49	41	16	48	36– 51	45	29	47	36– 44	40	25	29– 37	33	4	21– 32	27	15	34– 54	44	15	35– 51	46	10
Interorbital width	70– 84	76	16	73	64– 80	71	29	76	59– 73	64	25	69– 75	71	4	70– 86	77	15	59– 76	67	15	78– 92	85	10
Maxillary length	159–180	167	16	178	162–179	170	29	172	151–164	157	25	141–155	148	4	130–140	135	15	186–226	205	15	174–200	187	10
Greatest body depth	272–343	305	16	318	234–328	292	29	309	287–346	316	25	238–266	251	4	258–306	283	15	247–315	279	15	272–313	290	10
Caudal peduncle depth	113–128	117	16	119	115–133	125	29	130	131–146	138	25	113–122	118	4	94–115	101	15	116–135	126	15	95–107	102	10
Caudal peduncle length	194–238	222	16	220	203–244	220	29	220	202–243	224	25	242–276	255	4	201–245	219	15	225–269	245	15	189–216	205	10
Pectoral length	248–276	263	16	250	261–299	277	29	278	254–295	278	25	223–239	234	4	236–270	128	15	233–266	249	15	247–271	259	10
Pelvic length	193–262	216	16	217	198–228	212	29	203	178–223	206	25	185–218	205	4	204–229	251	15	186–226	205	15	202–235	218	10
Pelvic spine length	102–148	122	16	113	87–143	126	28	117	111–140	126	25	110–117	112	4	102–129	117	15	76–117	103	15	88–130	103	10
Longest dorsal spine	159–225	194	10	225	130–163	146	25	147	141–170	155	20	146–157	151	4	137–157	146	14	119–152	142	14	135–164	148	10
Shortest dorsal spine	78–107	95	16	91	99–121	108	28	100	80–101	90	23	96–106	101	4	95–112	104	15	88–106	96	15	98–121	108	10
Second anal spine	56– 88	71	16	67	53– 76	65	29	67	53– 69	62	25	98–109	101	4	53– 63	57	15	49– 76	62	15	53– 82	66	10
Third anal spine	78–115	94	16	89	74–107	95	27	91	80–115	95	23	92–100	96	4	77– 90	84	15	69– 93	81	14	75– 95	86	10
First dorsal ray	115–157	140	16	129	140–185	154	29	149	146–181	160	24	150–163	157	4	138–150	144	15	129–163	140	15	131–162	140	10
Longest anal ray	129–156	141	16	136	137–163	150	29	150	134–181	153	25	144–165	153	1	122–136	128	15	120–154	137	15	129–149	138	10
Standard lengths	82–211	--	--	176	99–210	--	--	129	78–144	--	--	68– 92	--	--	96–131	--	--	77–226	--	--	83–137	--	--

TABLE 2

Cheek Scale Counts for Seven Pacific Species of *Diplectrum*

	Rows					
	6	7	8	9	10	11
D. labarum	--	29*	16	--	--	--
D. sciurus	--	4	13	4	--	--
D. maximum	--	--	4	--	--	--
D. euryplectrum	--	--	17	3	--	--
D. pacificum	--	--	--	13	8	2
D. macropoma	39	--	--	--	--	--
D. eumelum	37*	2	--	--	--	--

* Count of Holotype

While this paper was in press an additional species, *Diplectrum rostrum* (Bortone, Copeia 1974 (1) : 61–65) was described from the eastern Pacific. *D. rostrum* may be distinguished from the species treated by us by the following combination of characters: Gill rakers 22–25, anal soft-rays usually 7, two light bands across snout below eye, black mark on operculum present. In overall appearance, *D. rostrum* is most similar to *D. pacificum*.

Calif. Fish and Game, 60(4) : 192–198. 1974.

ATTACKS BY THE WHITE SHARK, *CARCHARODON CARCHARIAS* (LINNAEUS), IN NORTHERN CALIFORNIA[1]

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This is a report on three shark attacks in northern California: an attack on a skin diver by a white shark in the channel between Bird Rock and Tomales Point, Marin County; an earlier attack on a skin diver, presumably by a white shark, at the same place; and an attack on a fishing boat by a white shark off Del Norte County.

INTRODUCTION

A number of shark attacks on swimmers and skin divers have occurred along the California coast. In some instances, a general description of the shark was offered by a witness who glimpsed some part of the shark during the frenzied moments of its attack. In others, a plausible identification of the species of shark involved was deduced from the shape and spacing of the tooth marks on the victim or on parts of his swimming equipment. Identifications based on such descriptions or on tooth marks have been recorded by Bolin (1954), Fast (1955), Gilbert, Schultz, and Springer (1960), Coppleson (1962), Garrick and Schultz (1963), Schultz and Malin (1963), Follett (1966). In one instance, the attacking shark was positively identified from a tooth fragment (Collier 1964).

This report describes three shark attacks—two on skin divers and one on a fishing boat. The attacks on the skin divers occurred twelve years apart at the same place. Two of the attacking sharks (including the one that attacked the boat) were identfied from tooth fragments.

ATTACK ON A SKIN DIVER NEAR TOMALES POINT

On May 28, 1972, about 1:30 p.m., PST, a large shark seized and seriously injured Mr. Helmuth Himmrich of Lodi, California, who was swimming in the channel between Bird Rock and the western shore of Tomales Point, Marin County, California. Tooth fragments removed from his wounds are identifiable, from the size and configuration of their marginal serrae (also called "serrations"), as those of the white shark, *Carcharodon carcharias* (Linnaeus), long known as the man-eater.

The precise locality (as computed from Mr. Himmrich's indication on U. S. Coast & Geodetic Survey Chart 5603, Nov. 1934) was 38°13′ 47″ N. lat., 122°59′29″ W. long. A fog bank lay about 300 feet above the water. The southwest wind was too light to cause whitecaps. The water was between 12 and 15 feet deep; it was murky, with much plankton; visibility was limited to 4 or 5 feet. Sea urchins covered the flat rocky bottom. No large algae were growing in the immediate vi-

[1] Accepted for publication April 1974.

cinity. The temperature of the water was not determined. The nearest place from which water temperatures are available was the Pacific Marine Station at Dillon Beach, about 1.4 miles north and 1.4 miles east from the point of attack. There, the water temperatures taken (at 4 p.m., PST, in the surf directly in front of the station) during the preceding eight days had varied from 12.0° C to 13.6° C, as follows: May 20, 12.0° C; May 21, 13.5° C; May 22, 12.5° C; May 23, 12.9° C; May 24, 13.6° C; May 25, 12.1° C; May 26, 12.6° C; May 27, 12.1° C. No temperatures were recorded for several days thereafter.

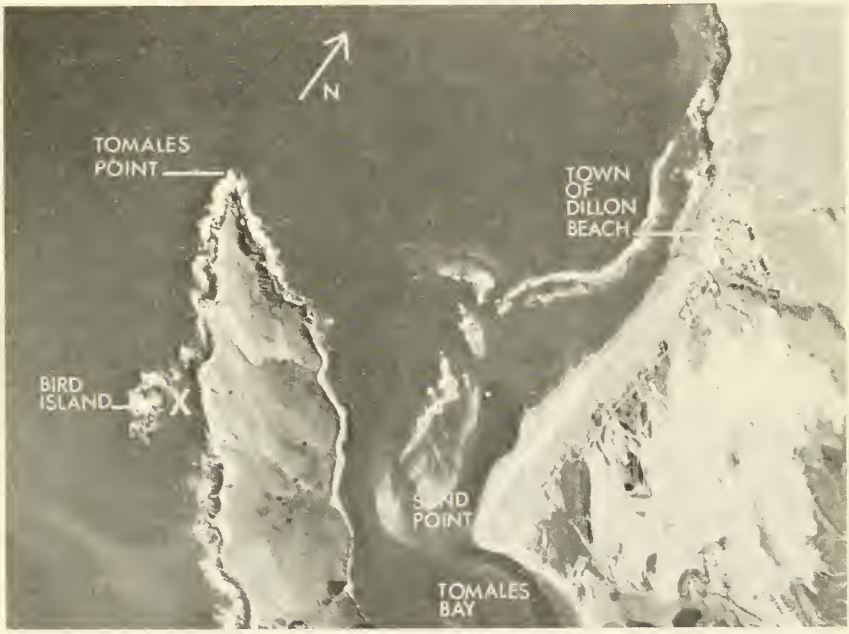

FIGURE 1. Aerial view of Tomales Point, Marin County, California, and adjacent Bird Rock. "X" indicates the place where two shark attacks have occurred. Photograph by Pacific Resources Aerial Survey, 1967.

Mr. Himmrich (Caucasian, age 31 years, height 5 feet 10 inches, weight 190 pounds) had been diving for abalones. There were no cuts or abrasions on any part of his body. He was wearing a nylon-lined neoprene wet suit, a face mask, gloves, and swim fins—all of which were black—and an orange inflatable life vest. He was carrying an abalone iron, most of its red handle concealed in his closed hand.

Mr. Himmrich's four companions were fishing nearby from an 18-foot boat equipped with an outboard motor. Four or five minutes before the attack, one of these anglers, using squid bait, had caught a large "seatrout" (*Hexagrammos* sp.)—the only fish that they caught at this place. No fish blood or parts of fish nor food had been dropped into the water. Mr. Himmrich had put five red abalones into a bag and had handed the bag into the boat. He had then dived and released a hook and sinker that had become fouled on the rocky bottom. After returning to the surface, he was lying face down and was just starting

to swim back to the boat (which was about 20 feet away) when he was seized by the right thigh immediately below the buttock.

Later, one of his companions, Mr. Charles Jones of Lodi, said, "It was a shark. About 8 to 12 feet of him came out of the water. He was dark bluish gray above and white below, and every bit of 12 feet long, and he was so broad it would have been hard for me to put my arms around his head."

In Mr. Himmrich's own words (June 6, 1972), "He grabbed ahold of me, and then when I moved he really clamped down on me. He brought me up out of the water, exeept my head and chest, which were in the water. He shook me and then he released me. He was going in the same direction as I was—toward the boat. I never did see him. My first thought was that it was a sea lion. After he released me I swam, butterfly fashion, to where they could reach my arms and pull me into the boat. They put me on my back, and I could feel my whole right leg going numb, but I never did lose consciousness."

After his companions had bound his thigh with a leather belt, they took him to Dillon Beach, where he received further first aid. A Coast Guard helicopter then transported him to Crissy Field, San Francisco. From there he was taken by ambulance to Letterman General Hospital, where he was attended by John E. Hutton, Jr., M.D., Lieutenant Colonel, Medieal Corps, U.S. Army.

Dr. Hutton summarized the injuries inflicted by the shark. The most serious of Mr. Himmrich's wounds was a circumferential incision, about

FIGURE 2. White-shark tooth fragment (Calif. Acad. Sci. 27158), length 11 mm, surgically removed from the leg of Mr. Helmuth Himmrich. Photograph by W. I. Follett, September 4, 1973.

9 inches long and 3 inches deep, immediately below the right buttock. From its appearance, it could have been made by a scalpel. This wound apparently would have been deeper but for the femur, which had barred the teeth from penetrating deeper. The belly of the underlying musculature had been neatly divided as if by a surgical instrument. The sciatic nerve was cleanly cut in two. In the back part of the leg behind the knee joint there was a wound about 3 inches long and $1\frac{1}{2}$ to $2\frac{1}{2}$ inches deep. Apparently, two teeth had penetrated this area, straddling the popliteal artery, veins, and nerve, and causing no damage to these vital structures. *This phenomenon probably saved Mr. Himmrich's life.*

A year later, some feeling had returned to the injured leg, and some muscle movement had become possible.

From the deepest wound, Dr. Hutton removed three small tooth fragments (California Academy of Sciences catalog no. 27158) that are referable to the white shark. The largest, 11 mm in length, bears 11 serrae, which form a cutting edge 10 mm long (Figure 1). For photographs of a number of teeth of white sharks, see Follett (1966).

PREVIOUS ATTACK AT THE SAME PLACE

Remarkably, the attack on Mr. Himmrich was the second shark attack at the same place. Mr. Frank I. Gilbert (Caucasian, age 48 years) of Petaluma, California, the victim of the previous attack, gave me (May 23, 1960) the following statement: "On April 24, 1960, about 1 p.m., PST, in bright sunshine, I was diving for abalones, without scuba. I was wearing a skinsuit of black neoprene, and black swimfins; only my hands were exposed. It was high tide and I was in about 20 feet of water, about 50 feet from the east side of Bird Rock, toward the mainland of Tomales Point. The water temperature was in the 50's. I swam against the current to where I knew there was a big submerged rock. I made one exploratory dive, picked up one abalone, and put it in the net at the surface. The water was murky; I would estimate the visibility as about 4 feet. I made another dive, picked up 2 abalones, took them up to the net, and was lying on the surface, face down, with my feet out behind me, kicking lightly, and resting. I was using a snorkel and face plate. I felt a tug on my right foot, but it was not violent. I rolled over on my back to see what it was, and could see the back and dorsal fin of a shark. I would estimate the height of the fin as 18 inches. I hollered to my partner, Loren Gossage, to get back in the boat because a shark was after me. I then realized that my boot was cut and the fin was gone, but I did not know that I was cut. There was no pain. I started splashing the water and hauled myself up on my tube and headed back for the boat. I later found that my right foot had been cut in 3 places: a $1\frac{3}{4}$ inch knifelike cut (requiring 11 sutures), slightly curved downward toward the ends, on the right side of the foot starting $\frac{3}{4}$ inch behind the base of the little toe; a half-inch cut on the front part of the bottom of the heel; and a deep $1\frac{3}{4}$ inch knifelike cut (requiring 14 sutures) from the bottom around to the back of the heel. I lost a lot of blood, but did not have a transfusion. I made a good recovery." The character of the wounds, and Mr. Gilbert's brief mention of the dorsal fin, suggest that his attacker was a white shark.

FIGURE 3. Mr. Henry Tervo pointing to scars on his boat "Hunter," made by teeth of attacking white shark. Photograph by Richmond Independent, June 16, 1960.

UNPROVOKED ATTACK ON A FISHING BOAT

Sharks occasionally attack boats—at times without apparent reason (see Coppleson 1962). Mr. Henry Tervo, a commercial fisherman of Eureka, California, told me (June 17, 1960) of an attack on his 36-foot boat "Hunter": "I was salmon trolling on September 10–12, 1959, about 3:30 to 4 p.m., PST, about 4 miles offshore, between False Klamath and the Klamath River, Del Norte County, California, in about 30 to 35 fathoms. The sea was choppy and the water warm and turbid. The bottom was probably mud. I judged that I had hooked a 'shaker' [undersized salmon] on my port line, and I was reaching down to release the clamp on the port side of the stern of the boat when I saw something coming at me like a torpedo. It was a shark, about 15 feet long. It grabbed the lower guard of the stern of the boat in its mouth. Its impetus raised its body and tail out of water to such a height that I thought it would topple into the cockpit. When it released itself it went around under the stern and came up on the starboard side. I went and got the gun and when I came back it was making a turn toward the boat again. Then it went down and I never saw it after that. Captain of Wardens Walt Gray and another warden took three teeth from the side of the boat while the boat was tied to the dock at Eureka. The photographer of the Richmond Independent [164 Tenth Street, Richmond, California] photographed the boat yesterday, but the scars had been largely obscured by the work done in dry dock." (Figure 3).

A tooth fragment (California Academy of Sciences catalog no. 26884) that Mr. Tervo removed from the stern of his boat is identifiable as the apex of a lower tooth (of the first or second row from the symphysis) of a white shark (Figure 4). Since the length of the tooth represented by the fragment is uncertain, determination of the length of the shark by means of a ratio comparable to that used by Randall (1973) is not possible. In comparison with the teeth of 10 white sharks ranging from 6 feet 3¾ inches to 16 feet 9 inches in length, the configuration (especially the width) of the fragment agrees best with that of a lower tooth (of the second row) of a specimen 10 feet 3¾ inches in total length and 625 pounds in weight (California Academy of Sciences catalog no. 26363).

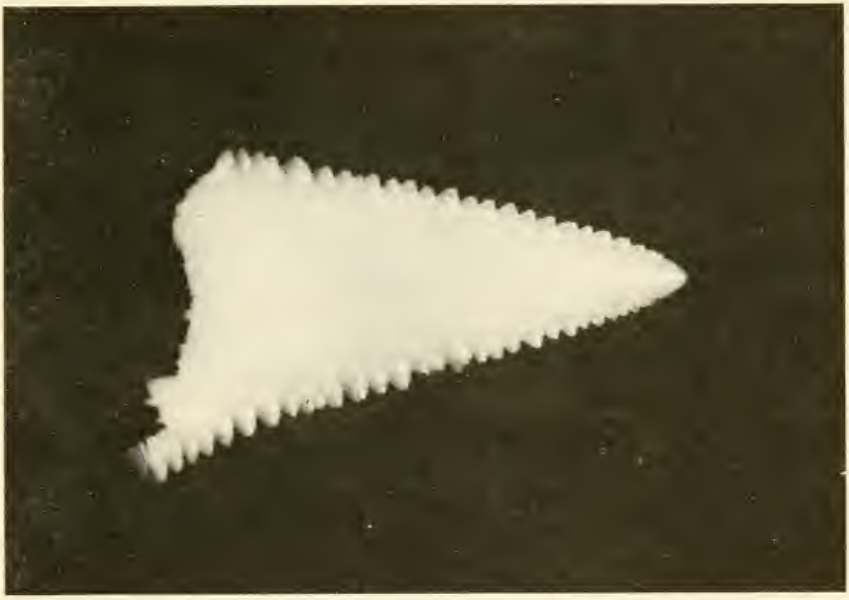

FIGURE 4. White-shark tooth fragment (Calif. Acad. Sci. 26884), median height 16.4 mm, removed from Mr. Henry Tervo's boat "Hunter." Photograph by W. I. Follett, July 25, 1973.

CONCLUSIONS

Years sometimes pass without an attack on any of the myriad of swimmers or skin divers in California waters (see Schultz and Malin 1963). But the potential danger of attack by a white shark, while extremely remote, is ever present along the coast of California—at all times of year.

ACKNOWLEDGMENTS

I wish to express my appreciation to Helmuth Himmrich for his detailed account of the circumstances under which the shark attacked him; to John E. Hutton, Jr., M.D., Lieutenant Colonel, Medical Corps, United States Army, for a description of the wounds inflicted upon Himmrich by the shark; to Edmund H. Smith, of the University of the

Pacific, for water-temperature records; to Frank I. Gilbert for the details of his encounter with a shark; to Henry Tervo for a description of the attack on his boat; to Lillian J. Dempster, of the California Academy of Sciences, for assistance with the manuscript; and to Maurice C. Giles, of the California Academy of Sciences, for enlargements of photographs of the shark-tooth fragments.

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Calif. Fish and Game, 60(4) : 199–204. 1974.

A BRIEF SURVEY OF SARDINE AND ANCHOVY POPULATIONS AT VIZCAINO BAY, AND OF THE SARDINE FISHERY OF CEDROS ISLAND, BAJA CALIFORNIA[1]

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A survey of sardines and anchovy populations of central and northern Baja California, complimented with samples and statistics of landings at Cedros Island in September and October, 1972, showed a definite decline in available stocks of sardines and a corresponding increase in the anchovy population, resulting in a decline in sardine catches at Cedros Island. Age determination revealed a lack of young sardines and an extraordinary abundance of young of the year anchovies.

Con los datos obtenidos de un crucero en la parte central y norteña de Baja California, complementados con muestros y estadísticas de los desembarcos de sardina en Isla Cedros, a finales de septiembre de 1972, se efectuó un análisis y se encontró que la población de sardina es muy reducida con el consecuente efecto en la pesquería. La población de anchoveta se presenta muy abundante. En la población de sardina están ausentes los individuos de la clase de edad de 1972. Mientras que en la anchoveta son extraordinariamente abundantes.

INTRODUCTION

The sardine fishery of Cedros Island, Baja California, showed continuous growth with few fluctuations from 1962 to 1967, reaching a peak of 13,000 metric tons. Since the end of that period the catch has declined as a result of a reduction in effort and a low availability of fish throughout the vicinity of Sebastian Vizcaino Bay. In 1972 the catch reached a low of 5,770 metric tons (Figure 1).

In an effort to analyze the condition and distribution of the sardine resource in relation to the commercial fishery, and to determine correlations between the age composition of survey samples and commercial landings, a cooperative study was arranged between the California Department of Fish and Game and the Instituto Nacional de Pesca of Mexico. The study was conducted in September and October 1972 aboard the Department of Fish and Game research vessel ALASKA and surveyed the west coast of Baja California from Ensenada to Asuncion Bay.

The cruise included a brief acoustic and midwater trawl survey and a series of night-light stations along the coast from Scammon Lagoon northward to provide an assessment of the sardine population. Commercial landings were monitored at Cedros Island cannery in conjunction with the survey.

[1] Accepted for publication June 1974.

FIGURE 1. Sardine landings at Cedros Island, 1962–1972.

PROCEDURE

The sonar (horizontally directed) and echo recorder (vertical sounding) equipment aboard the ALASKA was operated continuously along the preplanned transect lines for detection and measurement of fish schools. Sampling was conducted along the same lines with the 50 foot midwater trawl during hours of darkness for identification and age-length data (Figure 2).

Night-light stations of one hour duration were occupied at 8 to 10 mile intervals in nearshore waters. A blanket net was used to capture fish attracted to the light. All species collected were measured and recorded, and age and length data were taken on samples of sardines, anchovies, and Pacific mackerel. At Cedros Island, a sample of 100 fish

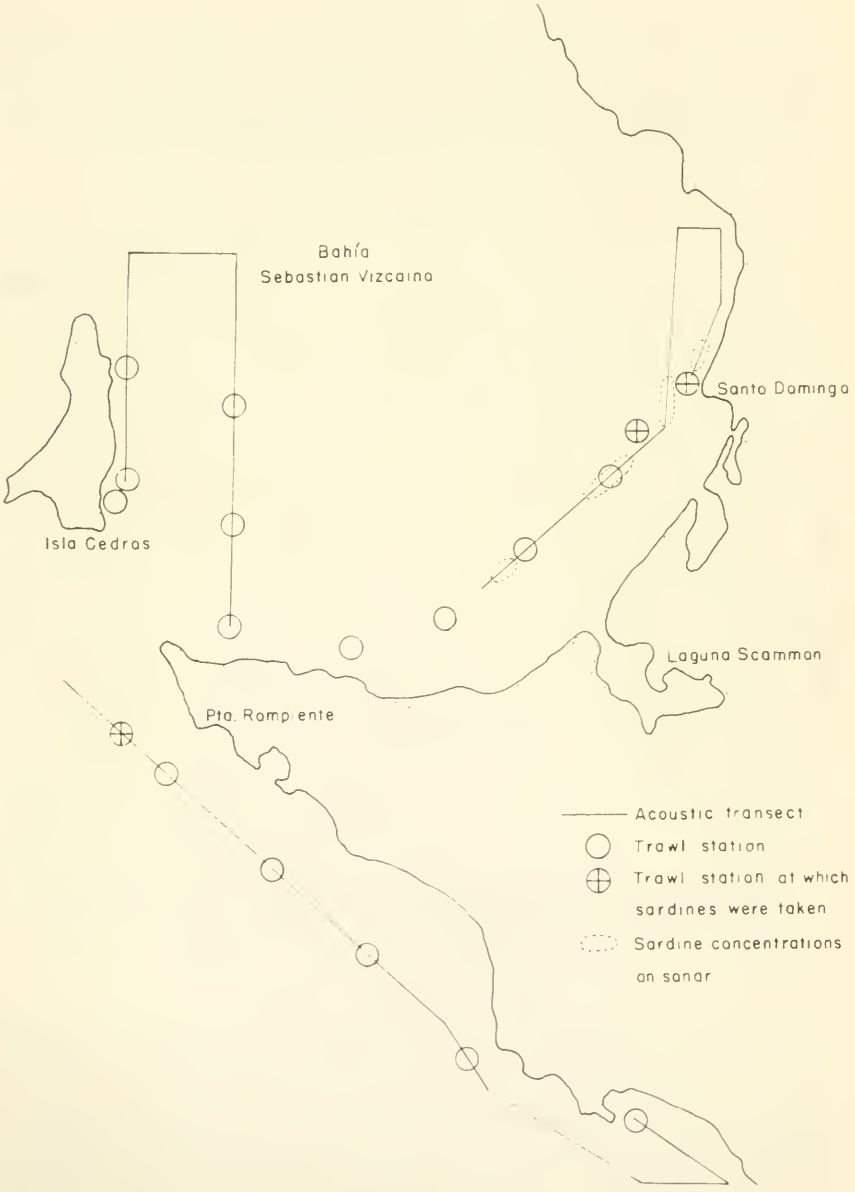

FIGURE 2. Acoustic lines and trawl stations occupied during the study.

was obtained from each commercial landing of sardines. All fish were measured and the total weight of the sample was recorded. From this sample 30 fish were sexed, weighed individually, and scales taken for age determination. Catch statistics were obtained from the cannery.

RESULTS

Sardine

Sardines were detected by sonar primarily in the vicinity of Santo Domingo and south to the mouth of Scammon Lagoon. A total of 38 schools was found over a distance of 30 miles, the largest schools (up to 60 m in diameter) being located 7 miles west of the mouth of Black Warrior Lagoon (Figure 2). Most schools sighted were small, approxi-

FIGURE 3. Percent occurrence by year class of sardines in the commercial catch and in

mately 10 to 15 tons each. A purse seiner from Cedros Island took 9.6 metric tons of sardines in this area in one set 2 days later. The only other landing of sardines during the survey period was 1.3 metric tons of sardines, mackerel, and bonito taken off Gran Canyon on the east shore of Cedros Island. A total of approximately 10 tons of sardines was landed by the two boats working during the survey period.

Sardines were taken in the midwater trawl at two stations near Santo Domingo and one station just west of Rompiente Point. Only two night-light stations produced sardines, both located near Santo Domingo.

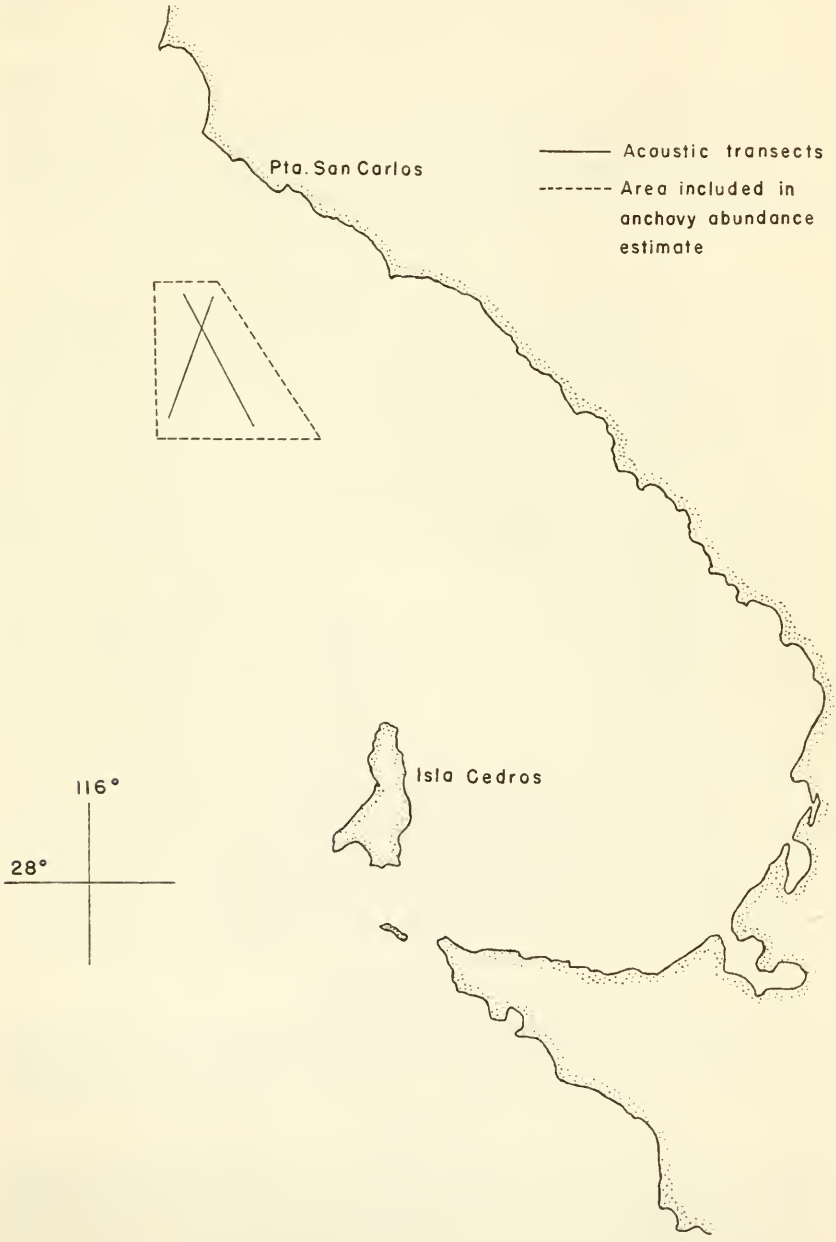

FIGURE 4. Area included in anchovy abundance estimates.

The samples taken by trawl and night-light were combined for age composition analysis. The age distributions for both survey samples and commercial catches from the survey area show similar patterns, and indicate that the fishery at this time is composed largely of two year classes. The highest percentages occur in the II and III year classes, with a sharp decline in IV and V year classes. Both sampling methods show a very low 1971 (I) year class and no young of the year (Figure 3).

The age distribution from our survey and from commercial landings seems to indicate a declining population with poor recruitment and few year classes. The apparent absence of young of the year may be due to a population distribution by age that eliminated 1972 fish from the survey area. Such a separation of juvenile and adult fish might be demonstrated by a more extensive survey.

Anchovy

Anchovies were the predominant species taken in the survey, occurring in 67% of the trawl hauls and 41% of the night-light station collections. Anchovies were well distributed, being found in all areas except where sardines were taken and between Cape Colnett and San Carlos Point near shore.

An incidental sonar transect made while enroute to Cedros Island revealed an extensive population of anchovies between San Carlos Point and Cedros Island. A total of 608 schools was detected by sonar along a 45 mile cruise track. Many schools were quite large, averaging 180 m in diameter and 13 m in thickness with an estimated biomass of up to 50 tons per school.

Anchovy schools were detected by echo sounder from 90 to 120 fathoms deep over a 100 to 900 fathom bottom. The school concentration extended offshore from 15 to 35 miles and at least 55 miles north of Cedros Island (Figure 4). After sundown the schools rose rapidly to the surface and dispersed. A night-light station occupied in the area produced a pure-catch of anchovies.

Anchovy school density averaged 33.4 schools per mile^2 for an estimated total of 10,856 schools in the 325 mile^2 area traversed by the acoustic transects. Calculations based on an average school biomass of 25 tons give an estimated minimum of 271,400 tons of fish in the area surveyed, or an average of 835 tons per mile^2 of sea surface.

More than half of the anchovies taken in Mexican waters and virtually all fish south of San Carlos Point were of the 1972 year class.

CONCLUSIONS

The marked absence of juveniles and the limited number of age classes lead us to believe that the stock and the fishery are in a critical situation due to low recruitment and high mortality, in addition to unfavorable environmental conditions and a constant level of exploitation.

The fishing industry of Cedros Island, which depends heavily on sardines, is declining as the sardine population declines. In the presence of a large population of anchovies it would seem that the industry could better sustain itself by diversifying and using improved methods of locating fish.

Calif. Fish and Game, 60(4) : 205–206. 1974.

NOTES

FEEDING BY MATURE STEELHEAD (*SALMO GAIRDNERII GAIRDNERII*) IN THE SPAWNING STREAM

Earlier workers have reported that adult steelhead do not normally, or commonly, feed in fresh water during spawning migrations (Chapman and Quistorff, 1938; Shapovalov and Taft, 1954). However, little empirical data on stomach contents has actually been published.

Adult steelhead food habits were studied in two tributaries of the Sacramento River in California. These streams, Deer Creek and Mill Creek, are both over 160 river kilometers from the ocean.

From October 1969 through January 1971 stomach contents of 83 mature, angler-caught steelhead (27 males and 56 females) were examined (Table 1). I identified these fish as steelhead and not resident rainbows on the basis of scale characteristics, similar to those discussed by Sumner (1945). Freshwater scale annuli counts revealed all fish examined had spent 2 years in fresh water prior to entering the ocean. Three of the fish had spent one summer in the ocean, while the balance had spent two summers there.

Patted-dry food items were weighed after sorting and removal of trichoptera cases. Only four of the 83 stomachs examined were empty. Trichoptera formed the major constituent of the stomach contents by weight and frequency of occurrence. Aquatic plants were the second-most abundant item. They were less abundant in January than in other months. Eggs of king salmon (*Oncorhynchus tshawytscha*) were common in November and December. Stomach contents appeared to be related to seasonal availability.

The average amount of material per stomach was small (1.82 g/kg body weight), and the ability of the fish to digest these items is not known. However, the frequency of occurrence of food items in the stomachs indicates some feeding activity. Early fall migration, and relatively small size of Sacramento River steelhead, as noted by Hallock, Shapovalov, and Van Woert (1961), may make feeding a necessity for these fish if they are to maintain themselves in the spawning streams until spring spawning periods.

ACKNOWLEDGMENTS

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TABLE 1. **Diet constituents of mature steelhead**

Month of collection	Number of fish	Fish weight (kg)		Wet weight of stomach contents (grams)	Stomach contents*													
		Mean	Range	Mean	Eggs of *Oncorhynchus tschawytscha*		Plecoptera >2 centimeters		Plecoptera ≷2 centimeters		Ephemer-optera		Trich-optera		Aquatic plants		Unknown	
					DEER CREEK													
					A*	B*	A	B	A	B	A	B	A	B	A	B	A	B
1969																		
October	5	2.34	2.80–2.05	2.19	--	--	--	--	2	20	--	--	43	80	34	80	21	80
November	18	1.36	0.99–1.97	3.71	19	22	12	17	1	6	1	6	28	78	27	78	12	94
December	12	0.98	0.75–1.50	2.01	12	33	11	25	6	8	6	17	19	75	41	92	5	33
1970																		
January	17	1.44	0.69–2.64	1.55	--	--	--	--	--	--	1	6	90	100	1	94	8	94
November	9	1.42	0.99–1.45	3.51	31	78	7	11	4	11	2	11	20	67	32	78	4	44
December	7	1.17	0.66–2.00	2.77	9	14	8	14	3	14	1	14	42	86	21	86	16	72
1971																		
January	3	1.31	1.30–1.36	0.98	--	--	1	33	--	--	2	33	80	67	6	67	11	67
					MILL CREEK													
1970																		
November	12	1.09	0.97–1.31	2.15	41	33	10	8	2	8	1	8	22	94	21	94	3	50

* A—Percentage weight of total contents.
* B—Percentage of stomachs containing food item.

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OBSERVATION OF UNDERWATER TOOL USE BY THE SEA OTTER, *ENHYDRA LUTRIS* LINNAEUS

Hall and Schaller (1964) stated "the method by which an otter detaches the abalone from the rock is unknown." Fisher (1939) noted that "each (abalone) shell had a large piece broken out of one side. How this piece is broken out under water is still a mystery; perhaps by pounding with a rock, perhaps by the strong canine teeth." Ebert (1968) sheds more light on abalone removal by citing a professional diver, Ernie Porter, who stated that "otters are frequently seen at the surface with softball-sized rocks. Diving, they carry a rock between their forepaws, locate an abalone, and with very short but powerful arm movements from the chest region pound it until the shell fractures." We have made observations which substantiate the collection of abalone by pounding with a rock theory.

On 2 February 1972, the authors were SCUBA diving on a Department of Fish and Game study in Hopkins Marine Life Refuge at a depth of 9.1–12.2 m (30–40 ft). Visibility was greater than 9.1 m (30 ft). While swimming station transects, a pounding noise was occasionally heard. A few minutes later we were harassed by a sea otter near the end of our transects. After searching and feeling our entire bodies and biting the exposed end of a snorkle, the sea otter surfaced. This behavior has become a common occurrence in our diving area. When the sea otter returned to the bottom, it located some desirable object deeply recessed about .61 m (24 inches) in a rock crevice within 3 m (10 ft) of where we were working. The sea otter picked up a flattish granite rock, covered with coralline algae, and began pounding the object with the rock. The sea otter then surfaced for 15–20 seconds, holding onto the rock. It then returned to the item and again commenced hammering. The sea otter hammered for 88 seconds with three breaks of about 5 seconds each, during which it would drop the rock and try to pull the prey from out of the crevice. When the food item failed to come free, the sea otter would pick up the rock and resume hammering.

The sea otter used two positions for hammering. It first pounded lying on its stomach with its head bent upwards so it could reach its prey. It would then change positions so as to lie on its back with its head turned to the side and pounded over its right shoulder after which it would again turn back onto its stomach.

In a 15 second period the sea otter pounded the food item 45 times for a rate of 3 hits per second.

After its second dive of 90 seconds, it again surfaced for 15 seconds. On its second ascent from the bottom, it forgot the rock and about 2.4 m (8 ft) off the bottom the sea otter turned, looked around and appeared to locate the rock and then surfaced. At this point we swam over the crevice to see what the sea otter was so avidly pursuing and observed an abalone 114.3 to 127 mm (4½ to 5 inches) in length, which was still attached to the rock. Fresh scar marks from the sea otter's pounding were evident. We then swam back to our observation point so as not to distract the sea otter.

Upon reaching the bottom on its third descent, the sea otter picked up the same rock and resumed pounding on the abalone. In 30 seconds the abalone was loosened. The sea otter then dropped the rock, took the abalone to the surface and ate it. We collected the hammering tool, a granite rock with a smooth oval shape, which has the following dimensions: 166 mm (6.54 inches) long, 95 mm (3.74 inches) wide, and 45 mm (1.77 inches) thick and weighing 879 grams (1 lb, 15 oz). The coralline algae and bryozoa were worn off the end by the pounding.

The abalone was not broken, but seems to have been jarred loose rather than smashed.

These observations are interesting in that without a tool of some sort the abalone was inaccessible to both man and sea otter.

Unfortunately, we did not have our camera on this dive, as so often happens when unusual and interesting observations are encountered.

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WESTERN RANGE EXTENSION OF STEPHENS' KANGAROO RAT (*DIPODOMYS STEPHENSI*), A THREATENED SPECIES

In the course of conducting ecological studies (Bleich 1973; Schwartz 1974) at the U.S. Naval Weapons Annex, Fallbrook, San Diego County, California, noteworthy range extensions of Stephens' kangaroo rat were obtained. Grinnell (1922) and Hall and Kelson (1959) described the distribution of *D. stephensi* as the San Jacinto Valley and surrounding areas of western Riverside and southwestern San Bernardino counties. Lackey (1967) extended the range as far south as San Luis Rey, San Diego County.

Thomas (1973) investigated the present distribution of *D. stephensi*, and presented a map of what he considered to be its current geographical range. Localities herein reported extend the range of Stephens' kangaroo rat approximately 8 km west of the southwestern boundaries indicated by Thomas (1973), and 11.2 km west of the localities near Bonsall which Lackey (1967) investigated. Stephens'

kangaroo rats are no longer extant at Lackey's (1967) Bonsall localities (Thomas 1973).

At the Fallbrook Weapons Annex, *D. stephensi* occurs in two distinct habitat types: the Haplopappus Association of the Coastal Sage Scrub Community, and the Annual Grassland Community. Both of these habitats are similar to areas described by Lackey (1967) as preferred by *D. stephensi.* Seven localities harboring populations of *D. stephensi* at the Annex have been documented. All but one of these are in the Annual Grassland Community (Figure 1). Stephens' kangaroo rats were most abundant in the Haplopappus Association (33.8/ha, Lincoln-Petersen Index), and less common in the Annual

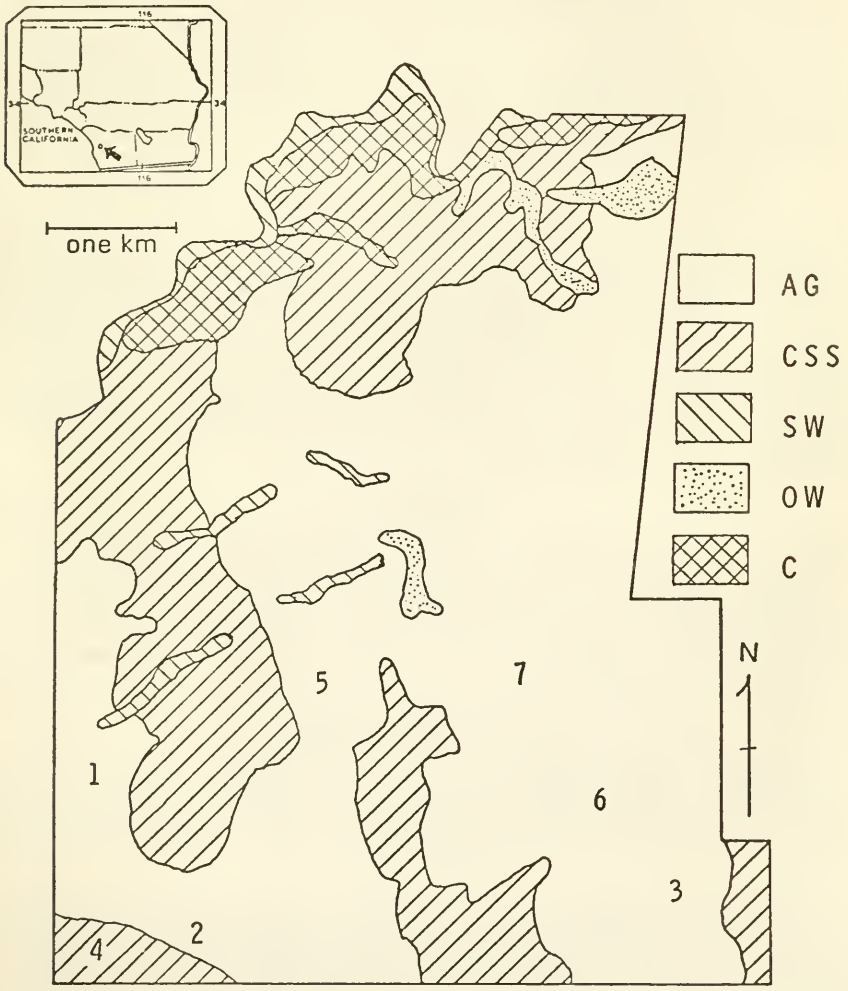

FIGURE 1. Distribution of *Dipodomys stephensi* at the Naval Weapons Annex, Fallbrook, California. Numbers indicate localities occupied by Stephens' kangaroo rats. Other symbols are as follows: AG—Annual Grassland Community; CSS—Coastal Sage Scrub Community; SW—Streamside Woodland Community; OW—Southern Oak Woodland Community; C—Chaparral Community.

Grassland Community (7.5/ha, Lincoln-Petersen Index) during the summer, 1972 (Bleich 1973).

The importance of considering suitable habitat in determining distributional ranges of small mammals was stressed by Csuti (1971), who reported range extensions of several species of kangaroo rats. The disjunct distribution of plant communities and habitat types in southern California makes it necessary to use extreme caution when determining distributional ranges of small mammals (Csuti 1971).

Urban expansion, accompanied by agricultural development of suitable habitat, has compelled the California Fish and Game Commission to classify *D. stephensi* as a "rare" species. These range extensions, therefore, are particularly significant because they document the occurrence of a threatened species in a sizable area, which, at least for the present, is not susceptible to human disturbance. The occurrence of a threatened species so far from its "established" geographical range gives rise to speculation that other populations of *D. stephensi* may exist in areas such as the eastern foothills of the Santa Ana Mountains of Riverside and San Diego counties.

ACKNOWLEDGMENTS

We are indebted to Rear Admiral J. W. William, Jr., Captains W. E. Betzer and F. R. Cassilly, and Commander J. R. DeView for permission to conduct biological research at the Fallbrook Weapons Annex. We acknowledge the field assistance of many persons, particularly Hans Megens, California State University, Long Beach. We thank Howard R. Leach, California Department of Fish and Game, for his interest and encouragement. Voucher specimens of *D. stephensi* from new localities herein reported are deposited in the Natural History Museum of Los Angeles County.

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FURTHER CONTRIBUTION ON NOMENCLATURE FOR MYSIDS IN THE SACRAMENTO-SAN JOAQUIN DELTA ESTUARY

In a recent attempt to clarify nomenclature for mysids in the Sacramento-San Joaquin Delta Estuary (Simmons et al., 1974), we indicated that *Neomysis intermedia* (Czerniavsky) should be the proper name for the species which had been called *N. mercedis* Holmes and *N. awatschensis* (Brandt). Evidence for the change was based on published analyses (Tattersall, 1932; Banner, 1954; Ii, 1964) and personal communication with experts available at that time. A newly available analysis based on a comprehensive set of new and old collections (Holmquist, 1973), however, restores the distinction between *N. intermedia* and *N. mercedis*. It indicates that the latter is the proper name for the *Neomysis* found in the Delta.

Holmquist confirms the conclusion that *N. awatschensis* is a distinct species (Ii, 1964). She also concludes that one of the major characteristics Tattersall (1932) originally used to distinguish *N. intermedia* from *N. mercedis,* the proportions of the fourth pleopod of the male, is a valid characteristic for distinquishing *N. mercedis* from *N. intermedia.* She further indicates two other distinquishing features not considered previously: 1) the shape of the labrum; and 2) the total length of the fourth pleopod of the male. The labrum of *N. intermedia* (and *N. awatschensis*) has "a long and pointed frontal process," whereas *N. mercedis* has "a short and broadly triangular protrusion." Further, the fourth pleopod of the male "reaches only to the latter half of the last abdominal segment" in *N. mercedis,* but "stretches to the middle or the latter half of the telson" in *N. intermedia* (and in *N. awatschensis*).

Dr. Holmquist has examined some of our specimens collected near Collinsville, California and identified them as *N. mercedis* (pers. comm. March, 1974).

N. awatschensis is restricted to the western Asiatic Pacific; *N. intermedia* occurs from the main islands of Japan to Alaska, and *N. mercedis* is found along the western coast of North America from Prince William Sound, Alaska, to San Francisco Bay, California (Holmquist, 1973). While both *N. intermedia* and *N. mercedis* are found in Alaska, it is unclear at present whether the two species meet.

ACKNOWLEDGMENTS

We thank James Carlton for his helpful suggestions and perusal of the manuscript. We also wish to thank Charlotte Holmquist for her determination of the *Neomysis, N. mercedis.*

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—Mary Ann Simmons, Richard M. Sitts, James T. Allen, and Allen W. Knight, Department of Water Science and Engineering and Graduate Group in Ecology, University of California Davis, California 95616. *Accepted June, 1974.*

NEW GEOGRAPHIC AND BATHYMETRIC RECORDS FOR FISHES FROM SOUTHERN CALIFORNIA

From 1967 to 1969, Lee, then marine biologist at the Santa Barbara Museum of Natural History, made or acquired numerous fish collections in the Santa Barbara Channel region. On reviewing the collections, we noted two geographic range extensions and 17 extensions of maximum or minimum depth ranges.

Reef finspot—*Paraclinus integripinnis*

In December 1967 and January 1968, a number of reef finspot were taken with dipnet and hand from tidepools at Serena Cove, Santa Barbara Co. (lat. 34°24′N., long. 119°34′W) by Lee and Mr. Pat Brophy. Three fish, 46–54 mm SL, were taken in December and three, 27–47 mm SL, in January. The previously published range was Santa Cruz Island, California to Almejas Bay, Baja California (Miller and Lea 1972) with the northernmost mainland specimen from Portuguese Bend, Los Angeles Co. (Hubbs 1952). The Serena Cove individuals extend the total range by about 20 miles and the mainland range by about 100 miles.

It is curious that the presence of this fish in the Santa Barbara area was not noted earlier, as the museum in Santa Barbara has a collection (00647) of reef finspot made by Dr. Elmer Noble in 1938 and 1940 from "Santa Barbara, California". No other data is available, however.

Meristic counts were made on the fish from the 1938–1940, 1967 and 1968 collections (Table 1). Counts for dorsal and anal fins were made after Rosenblatt and Parr (1969). In all cases the pectoral spine was so closely adnate to the first pelvic ray that it was not counted, following the example of Hubbs (1952). Undifferentiated caudal elements were not counted. In three cases, lateral line scales were not countable, due to scale loss.

Counts were generally within the ranges given by Rosenblatt and Parr, with two exceptions. Rosenblatt reported dorsal spine counts of XXX–XXXIII and anal soft ray counts of 19–21. Out of a total of 20 fish, we found dorsal spine counts to be XXVIII–XXXIII, one specimen having XXVIII and two having XXIX dorsal spines. Anal ray counts ranged from 17 to 21, two fish having 17 and eight having 18.

TABLE 1. **Meristic Counts on Reef Finspot from Santa Barbara Area**

Collection	D. spines	A. rays	C. rays	P_1	P_o	S_{11}
00328	33	II-21	13	3	13	40
(1967)	33	II-18	13	3	13	38
	33	II-19	13	3	13	36
	31	II-18	13	3	13	32?
	33	II-19	13	3	13	40?
	30	II-20	13	3	13	37
00647	29	II-20	13	3	13	39
(1938, 1940)	32	II-18	13	3	13	38
	32	II-19	13	3	13	38
	30	II-18	13	3	13	38
	33	II-18	13	3	13	37
	28	II-19	13	3	13	36
	30	II-19	13	3	13	37
	29	II-17	13	3	13	38
	30	II-18	13	3	13	37
	30	II-19	13	3	13	?
	31	II-17	13	3	13	37
	30	II-18	13	3	13	38
	33	II-18	13	3	13	39
	31	II-19	13	3	13	39

High cockscomb—*Anoplarchus purpurescens*

On 17 July, 1967, a 72 mm SL high cockscomb was taken off Rincon, Santa Barbara Co. (lat. 34°11′N, long. 119°33′W) by Mr. Pat Brophy. The fish was taken by otter trawl in 660 ft. Miller and Lea (1972) list a range of Pribilof Isls., Bering Sea to Santa Rosa Isl., with a depth range of intertidal to 100 ft. The previous southernmost mainland record was Pt. Arguello (lat. 34°34′N, long. 120°39′W) (UCLA W48-31). This Rincon individual represents a mainland extension of 110 miles and a depth extension of 560 ft.

It seems possible that small, crevice dwelling fish, such as the high cockscomb, are more common in deeper waters than suspected. The sampling effort for small benthic fish away from the immediate coast is slight, which may account for this lack of knowledge. As high temperature is probably a factor limiting the southern range of the high cockscomb, the depth at which this specimen was taken could be an example of submergence, the temperature at 660 ft being considerably colder than that inshore.

A number of decaying kelp holdfasts were present in the trawl, though the fish was not found in a holdfast. It is possible that the fish had been living in a holdfast before it broke free. The current patterns in the Santa Barbara Channel, however, are sufficiently unpredictable as to allow no possibility of determining from where the holdfasts had been carried.

California lizardfish—*Synodus lucioceps*

Several California lizardfish have been taken at depths greater than the previously recorded maximum depth of 150 ft (Miller and Lea 1972). The fish taken at the greatest depth was a 77 mm SL specimen trawled by Mr. Pat Brophy in 750 ft off Anacapa Island on 10 March 1968. On 9 February 1967, Mr. Brophy caught a 150 mm SL individual from 660 ft off the north end of Santa Cruz Island.

Bigfin eelpout—*Aprodon cortezianus*

One bigfin eelpout, 300 mm SL, was trawled in 240 ft off Rincon, Santa Barbara Co. by Mr. Pat Brophy, 13 July 1967. Miller and Lea (1972) list its minimum depth as 300 ft. This specimen extends the minimum depth by 60 ft.

Flag rockfish—*Sebastes rubrivinctus*

Two flag rockfish, 23 and 38 mm SL were trawled in 992 ft off Gaviota, Santa Barbara Co. by Mr. Pat Brophy, 23 October 1968. Until Rosenblatt and Chen (1972) split *S. rubrivinctus* and *S. babcocki*, depth records of the two species were lumped together, making it difficult to ascertain maximum and minimum depths for the two species. Miller and Lea (1972) list 600 ft as the maximum depth for the flag rockfish. These two individuals extend that record by almost 400 ft.

Longspine combfish—*Zaniolepis latipinnis*

Two longspine combfishes, 140 and 145 mm SL, were trawled in 660 ft from off the north end of Santa Cruz Island by Mr. Pat Brophy, 9 February 1967. Miller and Lea (1972) list its maximum depth as 372 ft. These two fish extend the maximum depth known by about 290 ft.

Yellowchin sculpin—*Icelinus quadriseriatus*

One yellowchin sculpin, 72 mm SL, was trawled in 660 ft off Rincon, Santa Barbara Co., by Mr. Pat Brophy, 17 July 1967. Additionally, Rim and Leslie Fay took a 37 mm SL individual from a tidepool at Pt. Dume during September 1968. Miller and Lea (1972) list the depth range of the yellowchin sculpin as 20–330 ft. These two fish extend the maximum depth range by 330 ft and the minimum depth range by about 20 ft.

Blackedge poacher—*Xeneretmus latifrons*

One blackedge poacher, 135 mm SL, was trawled in 240 ft off Rincon by Mr. Pat Brophy, 13 July 1967. Miller and Lea (1972) list its minimum depth as 300 ft. This fish extends the minimum depth by 60 ft.

Pink surfperch—*Zalembius rosaccus*

Seven pink surfperch, 40–118 mm SL, were trawled in 750 ft from off the north end of Santa Cruz Island by Mr. Pat Brophy, 3 March 1967. Miller and Lea (1972) list its maximum depth as 300 ft. These fish extend the maximum depth by 450 ft.

Pile surfperch—*Damalichthys vacca*

One pile surfperch, 280 mm SL, was trawled in 240 ft off Rincon, Santa Barbara Co., by Mr. Pat Brophy, 13 July 1967. Miller and Lea (1972) list the pile surfperch's maximum depth as 150 ft. This fish extends the maximum depth range by 90 ft.

Senorita—*Oxyjulis californicus*

One senorita, 160 mm SL, was trawled in 240 ft off Rincon, Santa Barbara Co., by Mr. Pat Brophy, 13 July 1967. Miller and Lea (1972) list its maximum depth as 180 ft. This fish extends the maximum depth by 60 ft.

Blackeye goby—*Coryphopterus nicholsii*

Five blackeye gobies, 41–87 mm SL, were taken by trawl in 180 ft off Topanga Canyon, Los Angeles Co., by Mr. Pat Brophy, in April 1969. Miller and Lea (1972) list 80 ft as the maximum depth for this species. These individuals extend the maximum depth by 100 ft.

Bay goby—*Lepidogobius lepidus*

Two bay gobies, 31 and 68 mm SL, were trawled in 660 ft off Rincon, Santa Barbara Co., by Mr. Pat Brophy, 23 January 1968. Miller and Lea (1972) list its maximum depth as 200 ft. These fish extend the maximum range by 440 ft.

California tonguefish—*Symphurus atricauda*

Two California tonguefish, 104 and 119 mm SL, were trawled in 660 ft off Rincon, Santa Barbara Co., by Mr. Pat Brophy, 17 July 1967. Miller and Lea (1972) list its maximum depth as 276 ft. This fish extends the maximum depth range by about 390 ft.

Hornyhead turbot—*Pleuronichthys verticalis*

One hornyhead turbot, 89 mm SL, was trawled in 660 ft off the north end of Santa Cruz Island by Mr. Pat Brophy, 9 February 1967. Miller and Lea (1972) list its maximum depth as 612 ft. This specimen extends the maximum depth known by about 40 ft.

Pacific sanddab—*Citharichthys sordidus*

One Pacific sanddab, 24 mm SL, was taken in a tidepool from Serena Cove, Santa Barbara Co., by Lee and Mr. Pat Brophy, 3 December 1969. The previous minimum depth (Miller and Lea 1972) was 30 ft. This individual extends that minimum depth by about 30 ft.

Longfin sanddab—*Citharichthys xanthostigma*

One longfin sanddab, 90 mm SL, was trawled in 660 ft from off the north end of Santa Cruz Island by Mr. Pat Brophy, 9 February 1967. Miller and Lea (1972) list its maximum depth as 444 ft. This specimen represents an extension of about 240 ft.

All fish listed are housed in the Santa Barbara Museum of Natural History. The collection numbers for these specimens are listed below.

Reef finspot—00328, 00417, 00647 Determined by R. Lee;
High cockscomb—00202 Determined by R. Lee;
California lizardfish—00026,00154 Determined by R. Lee;
Bigfin eelpout—00188 Determined by R. Lee;
Flag rockfish—00545 Determined by M. Love, R. Lee and D. Miller;
Longspine combfish—00151 Determined by R. Lee;
Yellowchin sculpin—00201, 00524 Determined by R. Lee;
Blackedge poacher—00186 Determined by R. Lee;
Pink surfperch—00135 Determined by N. W. Baker;
Pile surfperch—00177 Determined by R. Lee;
Senorita—00195 Determined by R. Lee;
Blackeye goby—00727 Determined R. Lee;
Bay goby—00206 Determined by L. Findley LACM;
California tonguefish—00198 Determined by R. Lee;
Hornyhead turbot—00133 Determined by R. Lee;
Pacific sanddab—00334 Determined by R. Lee;
Longfin sanddab—00122 Determined by R. Lee;

ACKNOWLEDGMENTS

We would like to thank Mr. Pat Brophy, Pacific Bio Marine, without whose untiring interest in marine life this note, among others, would not have been possible. Dan Miller and Bob Lea confirmed our identification of *S. rubrivinctus*. Ms. Nan M. Lawler, Santa Barbara Museum of Natural History, generously made the collection data and specimens available to us.

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BOOK REVIEWS

The Compleat Brown Trout

By Cecil E. Heacox; Winchester Press, N.Y., 1974; 182 p., illustrated. $12.50

There have been books published on the Atlantic salmon, the steelhead trout, and the Kamloops; I guess it was only a matter of time before someone felt there ought to be equal representation for the brown trout.

Mr. Heacox felt the need and wrote *The Compleat Brown Trout*. He has done a more than adequate job. Formerly the Deputy Commissioner of the New York Conservation Department, he has a strong background in fisheries biology and is an avid fly fisherman—specializing in dry fly fishing for brown trout! He has researched the technical literature thoroughly and has been able to translate it into an easy to read, informal text, drawing freely from his own personal experiences to illustrate pertinent points. He discusses the early history, the present worldwide distribution, and both the internal and external anatomy. Senses, trophisms, ecology, hatchery production, management, and food. All the work is accurate and the text isn't cluttered with footnotes or references, although he does include a bibliography of over sixty references for those wishing to read about brown trout in detail. There is a brief chapter on tackle; thankfully the author doesn't feel it is necessary to list all the flies a brown trout fisherman should carry or give involved directions for their manufacture.

All in all it is a very readable, enjoyable book. I was initially put off by the $12.50 price tag, but the cost of publishing books has undoubtedly increased as everything else has these days.—*K. A. Hasagen, Jr.*

The Birds Of California

By Arnold Small; Winchester Press, N.Y., 1972; 310 p. $12.50

Small's comprehensive description of California birds, their preferred habitat and migration characteristics is, in one sense, an updating of the 1944 classic, *The Distribution of Birds of California*, by Grinell and Miller. This new book, however, is less technical than the 1944 publication and should be a welcome addition to the bookshelves of amateur and professional birders, conservation workers and teachers.

West Coast birders have long been familiar with Small's capabilities as an ornithologist, teacher, writer and wildlife photographer. His expertise in these pursuits is clearly evident in the format and context of his book.

Small provides the reader with a complete checklist of all recorded sightings of birds in California between 1900 and 1974. The black and white illustrations of the book include the author's own photos of more than 300 of the 518 listed species.

More than half of the book consists of descriptions of 25 major categories of habitat and the species of birds normally found in each. Thus, *The Birds of California* is, by intent, a guide to fields to explore rather than a field handbook for bird identification.

Although not all taxonomists would be in agreement with the nomenclature employed by the author, Small has generally followed checklists of the American Ornithologist's Union (1957 checklist and 1973 supplement). However, in cases of departure from AOU listings he has used quotation marks or italics to identify species or subspecies he believes have debatable taxonomic status.

Small, in writing *The Birds of California*, has managed to produce a textbook for educators and an admirable reference work for conservation-oriented people. —*Paul E. Giguere*

The Wind Birds

By Peter Matthiessen; The Viking Press, Inc., New York, 1973; 160 p., illustrated. $9.95

"Birds of wind, or 'wind birds,' " is author Peter Matthiessen's description of the most varied and intriguing families of birds—the shorebirds. *The Wind Birds* is a beautifully written essay on the natural history of these remarkable creatures.

This book is an expanded and updated version of a text originally published in 1967 as part of *The Shorebirds of North America*. This earlier deluxe volume was edited by Gardner D. Stout and featured color paintings by Robert Verity Clem and species accounts by Ralph S. Palmer (The Viking Press, $22.50).

Peter Matthiessen is widely acclaimed as one of the finest nature writers of our time. In *The Wind Birds*, he presents a wealth of scientifically accurate information with a rare eloquence that will appeal both to the amateur naturalist and the professional biologist. The book is enhanced by 25 attractive line drawings by Robert Gillmor, one of the world's finest artists. This book is sure to be a treasured addition to the library of anyone interested in wildlife.—*Ronald M. Jurek*

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STATE OF CALIFORNIA
FISH AND GAME COMMISSION

Notice is hereby given that the Fish and Game Commission shall meet on October 4, 1974 at 9:00 a.m. in the Auditorium of the Resources Building, 1416 Ninth Street, Sacramento, California, to receive recommendations from its own officers and employees, from the Department and other public agencies, from organizations of private citizens, and from any interested groups as to what, if any, regulations should be made relating to fish, amphibia, and reptiles, or any species or subspecies thereof.

Notice is hereby given that the Fish and Game Commission shall meet at 9:00 a.m. on November 1, 1974, in the Board of Supervisors Chambers, County Courthouse, Redding, California, for public discussion of and presentation of objections to, the proposals presented to the Commission on October 4, 1974, and after considering such discussion and objections, the Commission, at this meeting, shall announce the regulations which it proposes to make relating to fish, amphibia and reptiles.

Notice is hereby given that the Fish and Game Commission shall meet on December 6, 1974 at 9:00 a.m., in Room 1138, New State Building, 107 South Broadway, Los Angeles, California, to hear and consider any objections to its determinations or proposed orders in relation to fish, amphibia and reptiles or any species or subspecies thereof for the 1975 sport fishing season, such determinations and orders resulting from the hearings held on October 4, 1974 and November 1, 1974.

FISH AND GAME COMMISSION
LESLIE F. EDGERTON
Executive Secretary

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